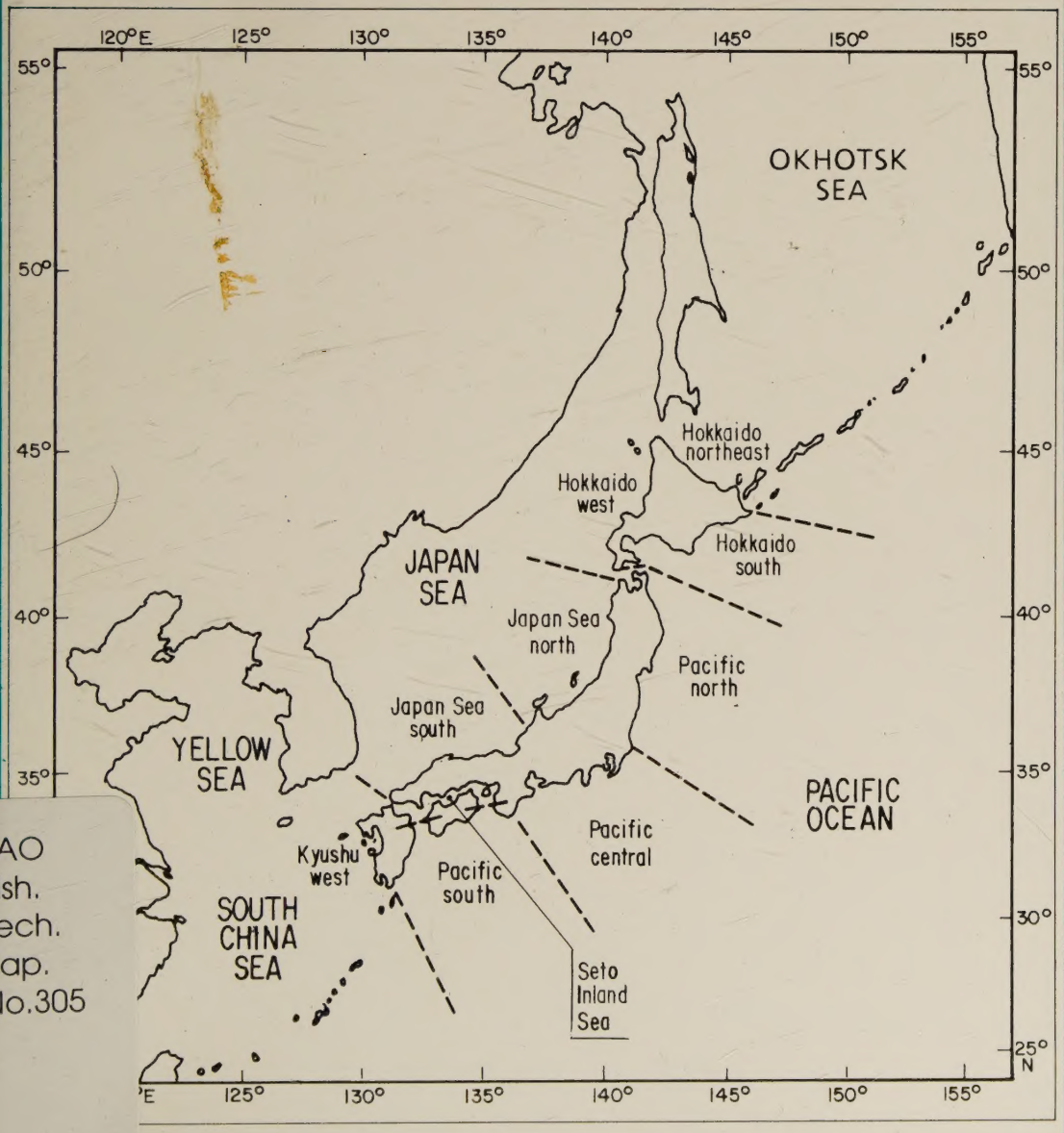
Management of multispecies resources and multi-gear fisheries

Experience in coastal waters around Japan



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Management of multispecies resources and multi-gear fisheries

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ABSTRACT

The management of multispecies fisheries employed in Japan has been reviewed from both a global and a region/subject-specific point of view. The discussion focuses on five major principles involved in the management of multispecies resources and multi-gear fisheries in the coastal waters around Japan, with examples from past experience.

The topics discussed include (1) the legal and political arrangements for the management and coordination of the fisheries, including the autonomous regulatory system established by the fishermen themselves, (2) the "successional fishing" employed in two small fishing communities, (3) the demersal fish fisheries along the entire coast of Japan, (4) the coastal pelagic fish fisheries, with special reference to large changes in stock abundance and species composition, and (5) the comprehensive utilization of resources in the Seto Inland Sea.

The last topic presents a clear example of a practical application of the comprehensive management measures being applied to a limited sea area where complicated multispecies resources are exploited. In particular, the discussion considers how to cope with changes in the resources brought about by either natural or man-made causes, including the successes and failures of past management.

An overall discussion of findings focuses specifically on a few critical problems that must be taken into account when the management of multispecies resources and multi-gear fisheries is planned and/or implemented. Finally, guidelines for such management are set down to facilitate the assessment of such a system in the countries where similar management issues have not yet been experienced.

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1. INTRODUCTION

The problems involved in the management of multispecies fisheries in Japan can be categorized into four major groups, namely (i) the incidental by-catch problems generated by the structure of fishing gear, (ii) the "successional fishing operations" 1/ directing fishing effort to a variety of fish species, (iii) the irregular and large changes in stock abundance and/or species composition of an exploitable fish community brought about by natural causes, and (iv) the efficient utilization of the ecosystem as a whole in a limited area/water.

1.1 Incidental By-Catch

Incidental catch problems are generated by fishing gear that catches more than one species by a haul or a shot, regardless of whether this is intentional or not. In a highly efficient gear such as bottom trawl or purse seine, the amount of by-catch taken is sometimes so large that it causes serious problems in the management of fisheries and resources.

Even when fishing operations are limited to a specific water, the species composition of the catch in each haul differs according to the time-spatial variation of the distribution pattern of the fish caught. This includes variation of species composition in the sea resulting from the infinite possibilities for the displacement of fish, variations in location and features of fishing grounds (oceanographic and/or bathymetric conditions), seasonal and/or diurnal differences in the fishing operations performed, etc.

The fishing strategy and tactics adopted by the fishermen also cause differences in the species composition of the catch. For instance, fishermen generally aim to catch prime species of high commercial value. As a result, fishing operations are usually characterized by frequent and quick changes of fishing ground from one water to another, which cause a substantial difference in the species composition of catches. The species composition of a catch is therefore the result of complicated and dynamic changes in both the (i) distribution pattern of fish taken and (ii) type of fishing method employed.

As a result, the amount and composition of incidental catch generally vary greatly even if the fishing gear employed is fairly strong selective action, with the exception of a few specific fisheries, e.g. skipjack pole-and-line, tuna longline, saury dipnet, herring drift gillnet or squid jigging fisheries, etc. It is technically very difficult to reduce the component of incidental catch in the entire catch as the ratio between the two is not a simple and independent parameter of fishing but the result of a combination of various factors and conditions, as described above.

There are two possible ways to deal with the by-catch problem. One is to manage the fishing to minimize the by-catch by adjusting gear and grounds as far as possible, and the other is to introduce suitable management measures specifically designed to reduce by-catch component of the fishery or fisheries in question. In Japan a combination of these two approaches has been employed, which has worked fairly well. However, it should be noted that the Japanese-type management scheme is unique in that the catch quota system has rarely been employed for management purposes, especially for catching finfish. This will be discussed in further detail in each of the later sections of this paper, with practical examples (see Section 2 for a discussion of the basic legal arrangements).

1/ See Subsection 1.2 for a definition, and Section 3 for the details.

In waters where the catch quota system is employed, one way to resolve the problem is to establish a special catch-quota system taking into account an allowable by-catch ratio in the total catch of the entire fishery in question. This method was actually employed for international fishing for demersal fish stocks on the Georges Bank during the 1960's and 70's. It worked fairly well. The major regulatory measures established and implemented by the International Commission for Northwest Atlantic Fisheries (ICNAF) for this purpose comprised a set of catch quotas for all the major species caught in the conventional waters of ICNAF.1/

By-catch also hampers the effective application of the regulations on mesh size for certain species. Since the theoretically derived optimum mesh size differs largely by species, it is technically impossible to apply a single mesh size regulation to a number of different species.

1.2 Successional Fishing

A structural feature inherent in small-scale fisheries also needs to be taken into account when examining multispecies problems. Local small-scale fisheries usually tend to employ simple and easy-to-operate gear aimed at catching high value fish species. Success in fishing operations is determined by various factors, e.g. fishing methods, accessibility of fishing grounds and the density of the target fish schools. Therefore, at the early stages of the development of these fisheries, the fishing gear employed was quite simple and the fishing grounds were confined mostly to nearshore waters. However, competition or conflicts between fishermen were not serious at that time since the fishing population was small.

As the fisheries developed, the fishing for a few specific fish species of high commercial value began and became more and more widespread. Competition among these fishermen thus arose in coastal waters, and was strengthened being coupled by a steady increase in the fishing population. Nearshore fisheries became less profitable for individual fishermen owing to a decrease first in the individual catch rate and second in the total catch, which boosted further competition among coastal fishermen. This general pattern can be seen during the development of many coastal fisheries before suitable management measures have been introduced. It should be noted, however, that a similar situation still exists in many coastal fisheries in the world today owing to a lack of adequate management actions.

In addition, the highly unstable nature of the fishing business needs to be taken into account when multispecies problems are examined. The catch rate and the total catch have always been subject to large fluctuations caused by various factors, e.g. fluctuations in abundance and density of target species, in oceanographic conditions, etc. It is traditionally said in Japan that the fishing business is a totally uncertain affair ("Ryo wa mizu-mono" in Japanese).

1/ The catch quotas were defined for 23 species/species-groups, which comprised cods, haddock, redfish, yellowtail flounder, winter flounder, witch flounder, scup, pollock, silver hake, red hake, white hake, other groundfish not specified, herring, mackerels, alewife, Atlantic saury, angler, sculpins, argentine, sharks, skates, other fish not specified, and squids. ICNAF became the Northwest Atlantic Fisheries Organization (NAFO) in 1978, in accordance with the establishment of the new regime of the sea. The definition of "conventional waters" has been substantially changed since this re-organization. However, the principle employed in the management of demersal fish stocks in the new area is the same as that employed before.

In order to minimize the uncertainty involved in fishing, it is better or safer for a fisherman to rely on multiple fish species rather than depending on only a single or a few target species. Such fishing operations can be performed with less risk and profitably by changing fishing gear in different seasons and grounds. Such operations also enable fishermen to increase the length of the fishing season or operation. The fishing strategy employed under such a multi-disciplinary philosophy can be called Successional Fishing (see Section 3 for details). It should be noted that almost all Japanese zcoastal fishermen employ this strategy.

However, it should be stressed here that full knowledge of the resources in question and adequate legal arrangements for proper management are indispensable for "successional fishing" mentioned above. The knowledge refers not only to the movements and behaviour of fish, which are closely linked to catchability, but also to the important biological features of the fish for management purposes.

It has usually been observed in recent years that a new fishery, once begun, grows very rapidly. The number of vessels employed increases as does total catch taken, which often results in an unfavourable impact upon the abundance and reproduction of the target stock(/s). If the stock abundance declines seriously as a result, the fishery may soon be compelled to shift target species, probably to a less valuable species than the one aimed at before. In the coastal waters around Japan such a process took place during the 1950's and the 60's, an example of which will be given in Section 6 of this paper.

1.3 Irregular Change in Stocks

Apart from the overfishing mentioned above, a shift in target species is sometimes required by the change in abundance caused by natural factors beyond human control. The large fluctuations frequently observed in the abundance of coastal pelagic fish stocks around Japan are typical examples. To cope with such natural fluctuations, the fisheries have to change target species in accordance with the substantial change first in the abundance of a specific fish species and second in the species composition of the exploitable community in the waters concerned. A fisheries forecasting service would be an effective way to reduce the uncertainty involved in fishing for these stocks. In Japan, the fisheries forecasting service has been actively employed for coastal pelagic fish stocks since the mid 1960's, and has contributed a great deal to the fisheries concerned (Yamanaka et al., 1988). Needless to say, however, such a service can only be exist when the resources research and adequate fisheries management are assured.

It has been generally observed that if the flexible strategy mentioned above is employed, the species combined total catch from the target fish community shows a fairly stable trend even when the abundance and the catch of individual fish stocks fluctuate greatly. This will be discussed in further detail in Section 5 of this paper.

1.4 Utilization of an Ecosystem as a Whole

When fisheries operate both extensively and intensively, harvesting various fauna and flora in the waters in question, the fishing strategy must be based on a different approach, namely the harmonious and systematic utilization of the ecosystem in the waters as a whole. In such cases, isolated management schemes aimed at a specific (or a few) living resource(/s) may not effectively protect that resource(/s) and the entire community in the waters. To achieve this end, full account must be taken of the followings; (i) the structure of the ecosystem in the waters in question, (ii) the inter species or inter species-group relationships among all components of the fish community and (iii) the socio-economic conditions of the fishing community.

Generally speaking, each fishery 1/ selectively utilizes only a segment of various living resources which compose an entire ecosystem in the waters. In the sea, the fish of commercial value are mostly at higher trophic levels, which implies that the total biomass of those fish is strictly limited by the biomass of prey at lower trophic levels, resulting in a relatively small quantity of commercially valuable fish. The biomass of planktivorous fish is, in contrast, generally huge but the catches are of lower commercial value.

In waters where a variety of resources are available at various trophic levels of the ecosystem, a careful choice must be made regarding the priority species to be utilized. For instance, a decision must be taken on whether to catch (i) only highly valuable fish in relatively small quantities but with higher profit, (ii) less valuable fish in large quantities, or (iii) a combination of these. Furthermore, the strategy decided on should be flexible. This will be discussed in further detail later in this paper (see Sections 6 and 7).

1/ "All the fisheries" referred to here include all the fishing activities harvesting some living resources in the sea, e.g. seaweeds, sea urchins, jellyfish, crustaceans, shellfish, cephalopods, other invertebrates, finfish and marine mammals, etc.

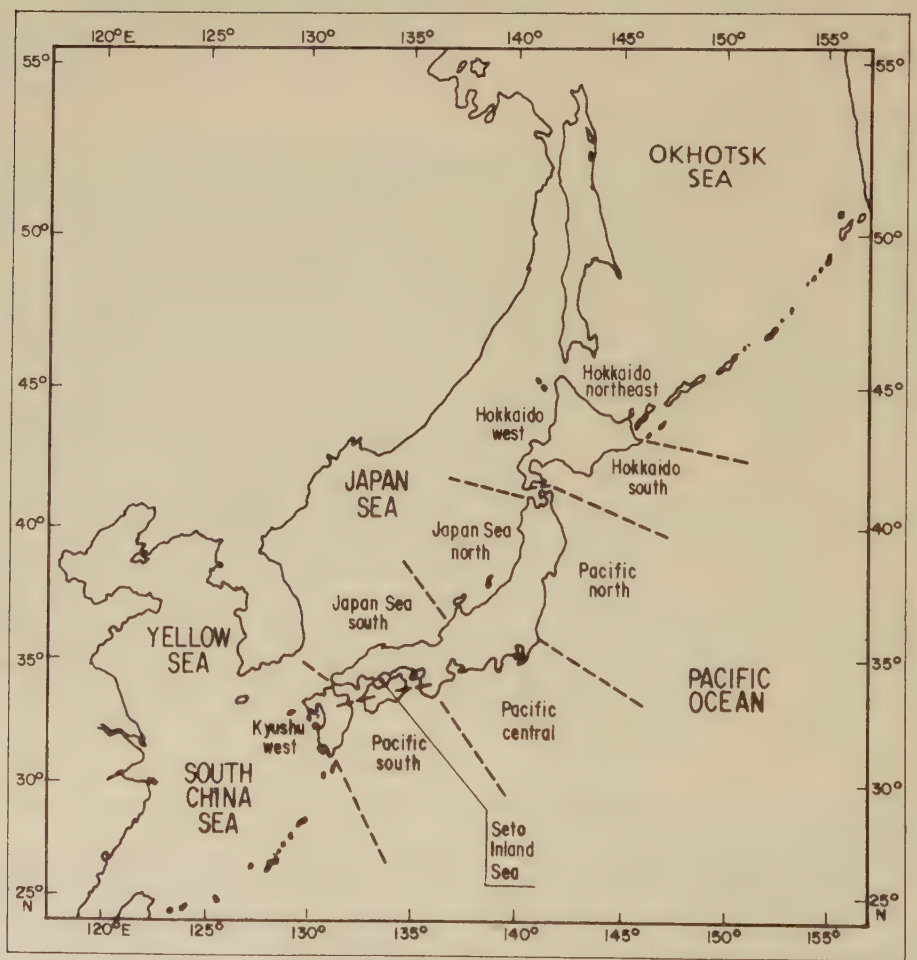

Figure 1. The coastal waters around Japan divided into sea areas for statistical and management purposes. Each of the sea areas is further sub-divided into a few local sea areas for management and co-ordination purposes (66 in total).

The authors present in this paper a discussion on the four different types of approach employed in the management of multispecies resources and multi-gear fisheries in Japan, with clear practical examples given. An overall discussion is then presented from a managerial and industrial point of view.

Figure 1 shows the division of waters around Japan into different sea areas for statistical and management purposes. Frequent reference will be made to these sea areas throughout this study.

2. MANAGEMENT SCHEME FOR NEARSHORE AND COASTAL FISHERIES

The authors review here briefly the fisheries management scheme for nearshore and coastal fisheries in Japan, since any discussion of specific examples needs to refer frequently to this basic scheme.

2.1 Basic System

The legal basis for fisheries management in Japan has been defined by the three major fisheries laws, namely (i) the Fisheries Law, enacted in 1949, (ii) the Fisheries Resources Conservation Law, 1951 and (iii) the Fisheries Co-operatives Law, 1948. Details of the entire system and its functions have already been well documented in a few other papers, e.g. Asada, 1973, Asada et al., 1983. The authors therefore present here only a brief review, focusing on the items most important for nearshore and coastal fisheries, discussed in this paper.

Four major principles, based on these three laws, have been adopted for the entire management scheme in Japan. They are (1) the establishment of the exclusive-use right in nearshore zones, (2) the enforcement of the control of total fishing intensity of various fisheries in defined waters during the specified season, (3) the establishment and enforcement of various conservation measures and (4) the promotion of co-ordination and co-operation among fishermen.

2.1.1 Exclusive-use right of nearshore zone

The Fishing-Right Fisheries defined by the Fisheries Law all fall into this category. They are divided into three categories, namely, (i) the setnet fishing-right fishery, (ii) the demarcated fishing-right fishery and (iii) the common fishing-right fishery. Table 1 shows the structure of these fisheries.

All the fishing rights are granted by the prefectural governor. However, the details of granting conditions and the management scheme to be employed afterwards have been strictly defined by the law. Furthermore, the governor, in granting a right, in establishing a new regulatory measure or in co-ordinating troubles when they occur, must hold consultations with the Sea Area Fisheries Coordination Committee, an independent local authority established in each of the sea areas surrounding the Japanese coast. There are 66 sea areas covering the whole coastal waters around Japan.

(1) Setnet fishing-right fishery

The fishery includes various setnet fishing in waters deeper than 27 m (sometimes 15 m) aiming at catching salmons, amberjack (yellowtail), sardine, mackerels, Atka mackerels, squids and a variety of other coastal fish species. The fishing right is granted to both individual fishermen/entrepreneurs and fisheries co-operatives on the coast.1/

1/ 193 rights were granted to fisheries co-operatives out of 1 844 rights issued in 1985.

Table 1. Fishing-right fisheries operating in nearshore waters around Japan. The rights are granted by the prefectural governor but details of procedures and conditions are strictly defined by the Fisheries Law.

Fishing right	Major Fisheries	Grantee
Setnet fishing	Various setnet fisheries; salmons, amberjack, sardine, mackerel, Atka mackerel, etc.	Fishermen/entrepreneurs and fisheries co-operatives
Demarcated fishing	Various types of aquaculture; seaweeds, oyster, other clams by seabed sowing, kuruma prawn, amberjack, sea breams, etc.	Fisheries co-operatives 1/ and fishermen/entrepreneurs
Common fishing	Various small-scale fisheries; shellfish/seaweeds collection, non-mechanized boat seine, beach seine, stake trap, bottom gillnet/longline/liftnet, handline, etc.	Fisheries co-operatives 2/

1/ Entitled to the first priority if an application is made.
2/ Exclusively granted to fisheries co-operatives.

(2) Demarcated fishing-right fishery

This fishery comprises exclusively various types of aquaculture, including seaweeds, oyster, other clams, amberjack, sea breams, other fish, kuruma prawn, etc. Although the grantees include both individuals/entrepreneurs and fisheries co-operatives, priority is given by law to the latter, if an application is made. In fact, the fishing rights for culturing seaweeds, oyster and clams have been almost exclusively granted to fisheries co-operatives and operated by their members under the self-regulatory scheme established by each co-operative. The rights for aquaculture granted to a fisheries co-operative sometimes play an extremely important role, in combination with the setnet and common fishing-rights, in the management of the entire nearshore zone on a self-regulatory basis, examples of which will be presented in the following section of this paper (Section 3).

(3) Common fishing-right fishery

The fishery covers almost all of the small-scale fisheries currently operating in nearshore waters. These include shellfish/seaweed collection, non-mechanized boat seine, beach seine, stake trap, bottom

gillnet/longline/liftnet, handline, etc., which usually form a multi-gear fishery in nearshore waters. However, no mechanized trawl is allowed to operate in nearshore waters around Japan. The fishing right is granted exclusively to fisheries co-operatives or joint-fisheries co-operatives to entrust the co-operatives with the management of fisheries and resources on a self-regulatory basis.

Once the fishing rights mentioned above have been granted, an exclusive-use right is legally generated in terms of specific waters (horizontally and vertically demarcated) and resources in the defined waters. Thus the grantees are sure to make use of the space and resources. However, various limitations on fishing are of course required, e.g. for conservation, propagation, navigation, communication and recreation purposes. These have been strictly defined by the Fisheries Law and other relevant laws and acts. If the rights are granted to fisheries co-operatives (fishing communities) and managed well, the area and its resources are treated by the community as its own property. Such a responsible attitude, when shared by the majority of the members of a community, undoubtedly facilitates the effective and harmonious utilization of nearshore zones. This is one of the key considerations commonly employed in the management of nearshore waters around Japan.

2.1.2 Limitation of total fishing intensity

The limitation of total fishing intensity has been enforced mostly through the licensing/granting scheme and partly by the implementation of various regulatory measures. As is shown in Table 2, there are 5 categories of licensed/granted nearshore and coastal fisheries. These are (i) minister licensed, (ii) minister approved, (iii) governor licensed but nationally registered, (iv) governor licensed but subject to the establishment of local regulatory measures and (v) governor granted but the details are defined by the Fisheries Law, discussed in the previous subsection.

In the first and second categories, the total fishing intensity (total number of licences by vessel size) is decided by the minister on a national basis. In the third category, the governor issues licences within the total allowable number allocated by the minister to each of the prefectures. The governor decides the limit in the fourth. In the fifth, the governor grants the fishing rights but the details are strictly defined by the Fisheries Law. In the fishing-right fisheries, however, when the rights are granted to fisheries co-operatives under the self-regulatory scheme, the details of limitations are decided by the co-operatives on their own within the framework defined by the central and the local government. Examples of this will be presented in Section 3 of this paper.

The total allowable fishing intensity is generally defined by triple limitations, i.e. (i) the total number of fishing vessels to be allowed by gross tonnage class within the total amount of (ii) the gross tonnage and/or (iii) the engine powers of all the vessels in the fishery in the defined waters. In the case of fixed gear such as setnets, stake traps, pots and traps, the total number of gears by type and size is limited in each of the defined waters.

2.1.3 Conservation measures

The conservation measures to be employed by both the central and local governments are defined by the Fisheries Resources Conservation Law. The major orders defined by the law include the prohibition and the regulation of

Table 2. Licensing and granting scheme of coastal fisheries in Japan.

Licenser/ grantor	Conditions	Major fisheries
Minister	Licensed	Offshore trawl (larger than 15 gross tons), large to "medium" type purse seine (larger than 40 gross tons), etc. 1/
	Approved	Saury stick-held dipnet, squid jigging, etc. 2/
	Licensed, nationally registered	Medium-type purse seine(5-40 gross tons), boat seine (5-15 gross tons) in the Seto Inland Sea, small-scale mechanized trawl smaller than 15 gross tons excluding the Seto Inland Sea,and smaller than 5 gross tons in the Seto Inland Sea, etc. 3/
Governor	Licensed, subject to local regulations	Various small-scale fisheries by vessels smaller than 5 gross tons; purse seine,boat seine excluding the Seto Inland Sea, surrounding seine,beach seine, non-mechanized seine/trawl, fixed gillnet, various types of angling, bottom longline, pot, trap, diving etc.
	Granted, defined by Fisheries Law	Fishing-right fisheries; 4/ setnet fishing-right fishery, demarcated fishing-right fishery, common fishing-right fishery.

1/ a) The "medium" referred to here is a term defined by law, but it is actually "large" in the context employed in this paper as the vessels defined are all larger than 40 gross tons.
b) Coastal tuna longline, coastal skipjack pole-and-line, medium-type offshore salmon drift-gillnet etc. are also included in this category but these are not multispecies fisheries. See Section 5 for the relevance of skipjack tuna fishing to the subject of this paper.

2/ These are not multispecies fisheries in the strict sense, see Section 5 for details.

3/ Small-type salmon drift-gillnet is also included in this category, but is not a multispecies fishery. See Section 6 for details of the limitation on licences in the "Seto Inland Sea".

4/ See Table 1 and previous subsection for details.

(i) catching, (ii) retaining and selling specific fish species, (iii) operating specific gears and vessels, (iv) discarding pollutants and (v) taking or displacing materials retained or deployed for conservation and propagation purposes. Under these headings, the law sets out in more detail conservation measures to be enforced in specific fisheries, resources and waters. These include (a) the establishment of conservation areas, (b) limitation on total fishing intensity, (c) permanent or seasonal closure of fishing grounds (d) a mandatory seasonal lay-off and (e) regulations on the size of fish to be caught and sold, etc.

2.1.4 Co-ordination and co-operation by fishermen

All Japanese fishermen and fishery processors are organized into various fisheries co-operatives and are strongly encouraged, by various legal and incentive arrangements defined by the Fisheries Co-operatives' Law, to co-ordinate their fishing operations to achieve harmonious utilization of waters and resources. The law also requires mandatory co-operation (i) with each other and (ii) with fisheries administrations in various administrative matters including the enforcement of management and conservation measures.

The law aims to improve first the socio-economic status of fishermen and fisheries processors, second the overall productivity of fisheries and last, the national economy. It therefore covers many areas of concern to the fisheries, especially those providing some kind of economic benefit or service to members, e.g. (i) banking and credit, (ii) the supply and sale of gear, fuel, ice, food and other daily necessities, (iii) credit/ mutual insurance and welfare, (iv) fishing by co-operatives, (v) transportation, wholesale operations, processing, storage and sale of catches and products, etc. However, those management and organizational activities have been integrated as important functions within the whole network of fisheries co-operatives' activities.

To introduce an example of the public nature acquired by fisheries co-operatives in Japan, it is worth noting that the majority of fisheries radio stations along the Japanese coast (599 out of 729 total radio stations along the coast in 1985 1/ have been organized and operated by fisheries co-operatives under the legal and incentive arrangements defined by the Law. The fisheries radio stations are now one of the most important transmission networks for fishermen, first for maritime safety, second for facilitating fishing operations and marketing (e.g. receiving fisheries forecasts or reporting the size of catches to wholesale markets), and third for providing a means of communication between fishermen and their families. The radio communication service, including a news service by facsimile, covers all the Japanese fisheries including offshore and long distance-fishing vessels.

2.2 Distinctive Features

One of the distinctive features of the fisheries management scheme in Japan, in contrast to those employed in other advanced fishing nations of the world, is that the catch-quota system has hardly been used, and very rarely for finfish. On the very rare occasions, the catch quota system is applied to several local resources, e.g. seaweeds, lobsters, shrimps, scallops and abalone. These are generally enforced by fisheries co-operatives as one of the self-regulatory measures entrusted to them by local governments. In these cases, the landing places are strictly confined to the designated local markets which are usually governed by the co-operatives concerned. An example of this is given in Subsection 3.2.

1/ The rest of the stations have been organized and operated by local governments.

In Japan, when a reduction or limitation of the total catch of specific fish species is required (e.g. for conservation, co-ordination or economic purposes), this is achieved by controlling total fishing intensity of the fisheries concerned rather than by limiting the total catch. This is usually done by either (1) reducing the number of operational vessels (abolishing or transferring licences in the long run, and/or laying off selected fishing vessels in the short-term, or (2) adjusting the fishing season (establishing or extending a period of closure).

The simplicity and effectiveness in these measures is far greater than for those required for direct control of the total catch in Japan. In fact, the monitoring and surveillance of the catch-quota system is practically impossible in Japan where numerous fishing vessels are operating at any given time and hundreds of landing places are scattered round the coast (there are 46 central and 734 local wholesale markets). This is why the catch-quota system is limited to local use in Japan, as described above.

Apart from the catch-quota system, the active participation of fisheries co-operatives in the management of coastal waters (both nearshore and offshore waters) is another distinctive feature of the Japanese system. There have been many reports from advanced fishing countries that co-operation given by fishermen has greatly facilitated the implementation of management measures. However, in the Japanese case the fishermen have moved beyond co-operation, in itself a rare enough phenomenon, worldwide. Both the fishermen and fishermen's association have actively participated in the enforcement of management measures under the self-regulatory scheme they themselves have established. The authors discusss this scheme in further detail in the following sections in this paper, with examples.

3. SUCCESSIONAL FISHERIES IN NEARSHOR WATERS

The "successional fisheries" are a complex of various fisheries in which successional fishing is employed, harvesting a number of fish species from a limited water. The species composition of a certain multispecies resource varies for both natural reasons as a result of fishing, as discussed briefly in Section 1 of this paper. The structure of the fisheries exploiting the multispecies resource also varies over time, but those changes can be controlled by man. An ideal combination for both can therefore be sorted out.

A fisherman performs successional-like fishing operations over the year, changing fishing gear and method to pursue the most profitable fish species in different seasons and grounds. If these "arbitrary" activities are allowed to continue in all fisheries without any form of control, various and serious problems arise concerning both the resources and the fisheries, e.g. serious deterioration of stocks and continuous conflicts among fishermen.

The successional fishing referred to in this paper is not a result of such arbitrary behaviour by fishermen, but is rather fishing under complete control, in which a well and carefully designed management scheme is employed. The changing of fishing from one to another (species, gear, ground, season, etc.) is therefore sometimes enforced by the regulatory authority regardless of fishermen's preference. Three basic principles have been established in successional fishing in Japan to justify such regulation. They include (1) the conservation of resources, (2) the harmonious carrying out of all fishing operations, and (3) a guarantee to ensure (a) the highest economic return within the framework of the management limits, and (b) equity among the entire community of fishermen in terms of profits. The regulatory measures to be employed vary greatly according to local conditions.

A multispecies resource formed in a specific water at a certain time is generally harvested by different kinds of fishing gear, especially in nearshore zones. However, the inclusion or exclusion of mechanized trawl fishing in the fisheries has important implications for the technical management of the resources, a fact which will be discussed later when considering a general management scheme in nearshore to coastal waters (see Section 6).

In Japan, mechanized trawl fishing has generally been prohibited in nearshore waters first for conservation and second for co-ordination purposes. The prohibition is strictly enforced especially in waters where an exclusive-use right has been established. For instance, only beach seine and non-mechanized boat seine are allowed as hauling gear in the common fishing-right fishery (see Section 2). The two examples presented here are nearshore zones, in each of which exclusive-use rights have been granted to fisheries co-operatives. No mechanized trawl operation is therefore allowed.

If the combination of the various types of fishing gear to be employed during the year is carefully designed and operations with that gear is effectively controlled by "successional fishing", the multispecies resources in a specific water can be harvested safely and harmoniously throughout the year. The authors describe here the fisheries management employed in two small-scale fishing communities in Japan to deal with such complex fishing operations. The location of the communities is shown in Figure 2.

3.1 "Hime-shima" Fisheries Co-operative

"Hima-shima" (Hime Island) is a tiny island with an area of about 7 km^2 located in the western part of the Seto Inland Sea, about 5 km off the northeastern coast of the Ooita Prefecture, Kyushu Island (Figure 2). The population, about 3 200, live together in a small village. Fishing is the most imortant industry in the village, followed by farming (vegetables and beef cattle). Most of those products are transported by ship and sold at large wholesale markets in urban districts of Kyushu. The fishermen number about 300 and all are members of the Hime-shima Fisheries Co-operative. The number of fishing vessels currently operating is about 340, composed mostly of small vessels of less than 5 gross tons, which characterizes the village as a typical small-scale fishing community in Japan.1/

The nearshore waters around the island provide very good fishing grounds for a variety of fish species of high commercial value. The entire Seto Inland Sea is highly productive of many coastal fish resources, a fact that will be discussed in more detail in Section 6. Hime-shima is located in one of the most productive parts of the sea, which is called "Suho Nada" (Suho Sea) as shown in Figure 2. The fishing gear employed is all traditional, including various types of angling/lining, bottom longlines and gillnets, boat seines, pots and traps, and composes a typical multi-gear fishery in the region. No mechanized trawl fishing is allowed in the waters around the island. The catch taken by this gear comprises a number of warm water species of high commercial value, i.e. puffers, various flatfish, sea breams, whiting, largehead hairtail, common Japanese conger, Japanese sea bass, Japanese barracuda, Japanese Spanish mackerel, grunters, octopuses, kuruma prawn and other prawns/shrimps, abalone, pen shell and other shellfish, sea cucumbers, etc., which form a highly complicated multispecies resource in the region all the year round.

1/ There are about 2 500 fisheries co-operatives formed by such small-scale fishing communities, each representing a village or a town. They are scattered along the entire coast of Japan.

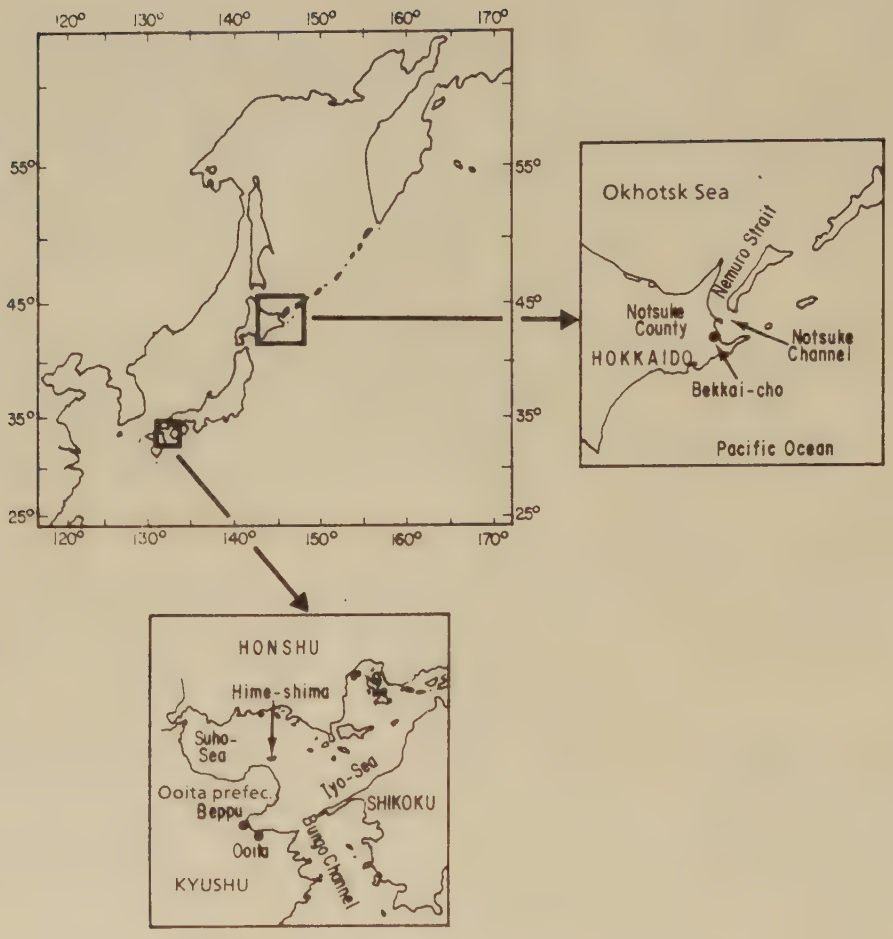

Figure 2. The location of the two small-scale fishing communities where "successional fishing" has been employed. They are discussed in detail as typical examples in this paper.

The Hime-shima Fisheries Co-operative, having first been entrusted with the task by the local government and second having obtained agreement from all its members, has established an autonomous self-regulatory scheme to achieve effective and harmonious utilization of the resources in the waters around the island. The principle employed in the scheme is the successive fishing intheir regulatory area. The scheme allocates fishing grounds and seasons to each of the various types of fishing gear mentioned above by using a Fishing calendar. The fishermen shift their fishing grounds and change gear according to the calendar. The principle employed in the allocation of grounds and types of gear has been derived mainly from traditional fishing rules which have been used by the fishermen of the island for a very long time, going back even before modern and democratic legal arrangements were established.

No serious conflict has occurred between the fishermen in the waters, with the exception of that caused by illegal piratic fishing by outsiders. It should be noted that seaweed culture (in winter) and kuruma prawn culture (in summer) are also incorporated in the calendar as important rotation elements for the whole fishery. This is one of the most advantageous features of exclusive-use rights for coastal zones granted to fisheries co-operatives, a feature that has been strictly defined and guaranteed by the Fisheries Law (see Section 2). Throughout the implementation of "successional fishing", no serious decline of exploitable stocks has been experienced, nor has any sign of overfishing been observed in the Hime-shima waters in recent years.1/

The total amount of production is small compared with medium- to large-scale fisheries in offshore waters. However, the net income of individual fishermen has been fairly high and stable throughout the seasons and years, being boosted by earnings from successional fishing operations. It should also be noted that the fisheries co-operatives provide a great deal of help in keeping market prices of their members' landings and products high. This is achieved through various activities, especially by post-harvest handling of the catch, e.g. in live rearing, storing in modern cold storage, processing, marketing for local consumption, shipment of the landings and products to the large central wholesale markets on Kyushu Island (to Oiita, the capital of the prefecture, or Beppu, a large health resort city with hot springs), all of which is made available by the common facilities owned by the co-operative (see Section 2.1 item, (4) for the legal basis and arrangements).

3.2 "Notsuke" Fisheries Co-operative

The "Notsuke" Fisheries Co-operative has been organized by the fishermen in a small town named "Bekkai Cho" (Bekkai town) in the "Notsuke Gun" (Notsuke county) along the east coast of Hokkaido (see Figure 2). The town is situated on the Nemuro Strait between the Okhotsk Sea and the Pacific Ocean, or between Hokkaido and the southernmost tip of the Kuril Islands.2/ The number of fishermen in the town is about 250 and total annual fisheries production is about 9 000 tons. This is a typical small-scale fishing community in Japan, quite similar to Hime-shima village, discussed in the previous Subsection (see Footnote in Subsection 3.1).

1/ Overfishing did take place during the 1950's and 60's over the entire Seto Inland Sea, especially of fish of high commercial value at higher trophic levels. However, most of these stocks have recovered in recent years, a phenomenon of which wil be discussed in further detail in Subsection 6.3.3.

2/ The central part of the Strait is locally called the Notsuke Channel (see Figure 2).

The fish resources available in the nearshore to coastal waters of the Notsuke region are entirely boreal. They are, however, categorized into two different groups by their biological features and availability to fisheries. Namely, (i) salmons that are anadromous, highly mobile and strictly seasonal and (ii) other sedentary coastal resources some of which are available, in turn, all the year round. This is one of the distinctive features of the region (i.e. a mixture of migratory and sedentary resources) in contrast to that in the Hime-shima waters where resources are composed mostly of sedentary species. As a result, a region-specific approach is required for management of the Notsuke waters, which is summarized below.

Benefiting from the favourable conditions in surrounding waters,1/ the resources in the latter group are very rich, being composed of a number of finfish including both pelagic and demersal types, shellfish, prawns/shrimps, seaweeds and other fauna and flora. This includes Pacific halibut, plaices, soles, saffron cod, Atka mackerel, Japanese sandfish, smelts, sculpins, Japanese ice goby, sharks, skates, squids, octopuses, surf clams and other shellfish, crabs and shrimps, seaweeds, sea squirts, sea cucumbers, etc., which form a highly variable multispecies resource in the waters all the year round, changing its species composition (and thus availability of species to fisheries) in different seasons.

Salmons, which are one of the most profitable target species-groups among boreal resources, are caught by a few specific types of gear such as setnets, drift and fixed gillnets, while the other species are harvested by small-scale multi-gear fisheries including setnets, gillnets, angling, bottom longlines, purse seines, pots/traps, boat seines etc. No mechanized trawl fishing is allowed in the regulated area of the "Notsuke" Fisheries Co-operative.

The successional fishing employed in these particular waters can be divided into two different types: (i) a combination of salmon fishing and other fishing and (ii) a combination of different fishing within the "other fishing". The important tasks that must be undertaken for regulatory purposes are there (a) the suitable allocation of fishing grounds and seasons to specific fisheries in order to minimize by-catch problems, (b) proper limitation of the number of fishing vessels and/or types of gear in an allocated fishing ground/season in order to ensure first the even distribution of fishing effort (over the area and over time), and second the effective enforcement of conservation measures, and (c) ensuring equity among the fishermen (members of the co-operatives) in terms of economic gains.

To meet this end, the co-operative has established an autonomous management scheme under the guidance and incentives given by both the national and the local government. It has established first the Fishing Right Management Committee, within the framework of the co-operative, as an official consultative authority to allocate the fishing grounds and seasons and to establish the regulations mentioned above. Then allocations and various measures, having been discussed with this committee and agreed upon by the members, are implemented by the co-operative (Nagaskai, 1983).

1/ The waters usually receive an inflow of highly nutritious waters from both the Pacific side (from the Oyashio) and the Okhotsk Sea side (from the outflow of the Okhotsk gyre), and occasionally from the warmer waters of the Kuroshio extensions (Chikuni, 1985, Yamanaka et al, 1988).

When allocating fishing rights to individual fishermen, equity among members is carefully taken into account. For instance, a fisherman who has already acquired a major profitable fishing right in a year (e.g. salmon setnet fishing or smelt gillnet fishing) is not allowed another major fishing right in other fishing (e.g. smelts, shrimp and sea urchin fishing) during the rest of the year even after the fishing season for salmon or smelt fishing is over, but is allowed to participate in minor fisheries (e.g. sandfish, saffron cod, octopus and sea cucumber fishing). A fisherman who owns only a minor fishing right is allowed to switch to any other minor fishing during the defined season.

The gross income of the individual fisherman during the previous fishing season is also taken into account when allocating fishing to the members at the beginning of the year, in order to ensure a certain equity in the long run. For instance, the fisherman who has earned a certain amount of gross income from a specific fishery during the year will not be allowed to operate the same fishery or another major profitable fishery the following year. The relationship between various levels of income in one year and the possible entitelement to specific fishing rights the following year has been strictly defined by the self-regulatory scheme established by the co-operative.

Regarding the autonomous regulations, a nuumber of measures for each of the specific target fish species and the applicable gear have been established and enforced by the co-operative. For reasons of space the authors present here only a few selected examples.

Gillnet fishing; for smelt, saffron cod and sandfish

Limited fishing season (to twice a year) mesh size, amount of gear on board, closure of ground.

Gillnet fishing; for sculpins

Limited amount of gear on board, mesh size, closure of season and ground.

Bottom trap fishing; for Atka mackerel, saffron cod and flatfish

Limited fishing season, size of gear, total number of traps (up to 800).

Beach seine fishing; for flatfish, smelt and ice goby

Limited fishing season, closure of ground, temporary closures frequently employed depending on the distribution of salmon fry (for the conservation purposes).

Gillnet fishing; for sharks

Limited season, mesh size, amount of gear on board, total number of vessels (up to 50).

Sailing trawl fishing; for "Hokkai" shrimp 1/

(a) Limited number of vessels, season (twice a year, summer and autumn), shrimp size (smaller than 8.2 cm).

1/ "Hokkai shrimp" is the English name defined by FAO; its scientific name is Pandalus kessleri Czerniavsky (Holthius, 1980).

(b) Catch-quota: 1 600 kg per vessel per year for the fishermen who were not engaged in salmon fishing in spring of the same year, 1 400 kg for fishermen who engaged in salmon fishing.1/

(c) Mandatory catch of trash fish: each vessel has to catch more than 500 kg of trash fish during each of the fishing seasons (1 ton in a year) and undertake to sell it to the co-operative, a requirement that aims to reduce the predators of the shrimp in the fishing ground.2/

Pot fishing; for crabs

Limited season, number of pots, number of vessels (6 vessels smaller than 5 gross tons and 9 over).

Thus all fishing activity in the region has been carried out harmoniously and stably. Total production is small, at about 9 000 tons per year, compared with the other medium- to large-scale fisheries in offshore waters. However, the net income of the individual fisherman is rather high. Furthermore, no serious conflict has arisen among the fishermen, nor has there been any deterioration of resources, while such occurrences might have happened if the management measures mentioned above had not been adopted.

3.3 An Overview

It would be difficult to find two examples like those described in this section in most parts of the world. However, these are quite typical and extremely common all over the nearshore zones around Japan. About 2 500 small-scale fishing comunities (fisheries co-operatives at a village/town level) have been fishing in this way under management schemes established by themselves with the same aims as those described above, namely to exploit various multispecies resources using a variety of multi-gear fisheries, regardless of differences in the species composition of the fish community to be harvested (i.e. boreal in the north, temperate in the central zone and subtropical in the south).

These features will be discussed in more detail in Sections 6 and 7 of this paper, but two facts need to be specially emphasized here: (i) there has been no serious conflict or series of conflicts among multi-gear fisheries and small-scale fishermen, and (ii) there has been no serious change either in stock abundance of a specific stock or in species composition among multispecies resources in nearshore zones around Japan in recent years.3/ These stocks may have been supported partly by the highly productive environment, benefiting from favourable oceanographic conditions in the waters around Japan (as discussed by Chikuni, 1985). The authors, however, are inclined to evaluate highly positively the employment of the Japanese-type "successional fishing" under self-regulatory schemes as one of the most important reasons for the success in management of the fisheries and their resources.

1/ One of the very rare instances of a catch-quota system being employed in Japan (see Subsection 2.2).

2/ A unique regulation, but interesting and thoughtful.

3/ Overfishing has, however, once occurred in some waters (see Footnote 2/ in Subsection 3.1).

4. DEMERSAL FISH FISHERIES AROUND JAPAN

4.1 Environment and Total Catch

The continental shelf (shallower than 200 m) around Japan is narrower than those in neighbouring seas, and has an area of about 424 000 km^2, compared to about 620 000 km^2 for the Okhotsk Sea and ambout 940 000 km^2 for the Yellow Sea to East China Sea (see Figure 3). Even when the continental slope area, ranging from 200 to 500 m in depth (128 000 km^2) is taken into account, the total area available for demersal fish fisheries is very small at about 552 000 km^2. However, the total catch of demersal fish taken from these narrow waters has been substantial at about 1.8 million tons annually in recent years.

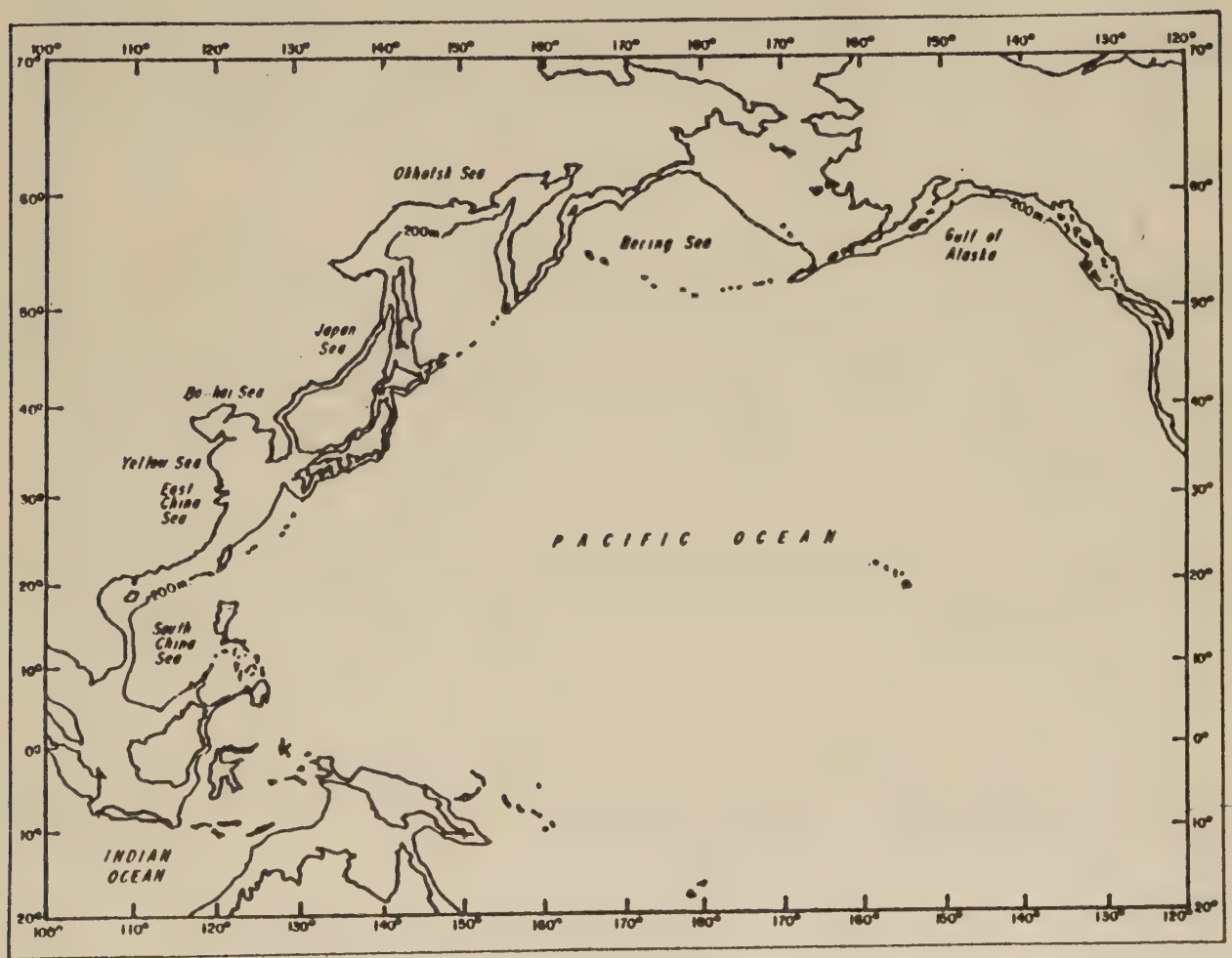

Figure 3. The extent of the continental shelf area (shallower than 200 m) in the waters around Japan and adjacent seas.

The total catch increased steadily from 1968 to 1977 from about 1.2 to 1.8 million tons. This was achieved chiefly by larger catches of Alaska pollack and sandlance (both fish of low commercial value) from the northern waters, i.e. the Okhotsk Sea, the northwestern Pacific along the Japanese coast, and the northern Japan Sea. The increase in the catch of these fish was stimulated by the increased demand for raw material to produce minced-meat ("kamaboko") for the former species, and for feeding material for aquaculture for the latter (see Subsection 6.4 for an example of the latter).

A variety of species are included in the total catch, including sharks, skates, bastard halibut and other flounders, plaices and soles, Pacific and saffron cods, Alaska pollack, Atka mackerel, Japanese sandfish, rockfish, sculpins, Japanese argentine, Japanese butter fish, daggertooth pike-conger, largehead hairtail, croakers, lizardfish, red and crimson sea breams, black and yellow sea breams, threadfin breams, tilefish, grunters, gurnards, perches, sandlance, gobies, pony fish, flathead, sea robin, filefish, various prawns and shrimps, crabs, cuttlefish, squids and octopuses. In Japan, the numbers of demersal fish species commonly sold in wholesale markets exceeds 250, most of which are taken from various types of multi-species demersal fish resources distributed around Japan. These are summarized below.

Much of the total catch has been taken from the northern fishing grounds. For example, in recent years about 30 percent of the total demersal fish catch has been taken from the waters along the northeast coast of Hokkaido bordering the Okhotsk Sea (see Figure 1 for the location of the region). This is due first to the large abundance of several boreal species in the northern fishing grounds and second to the high density of those stocks. Table 3 shows this clearly.

4.2 Species composition

The species composition of the catch differs greatly by region, and the number of species involved is generally smaller in the north and larger in the south. They are summarized as follows;

4.2.1 Pacific Ocean (see Figure 1 for the region)

Hokkaido, northeast;

Most of the catch is composed of three major species, i.e. Alaska pollack, sandlance and Atka mackerel. The combined catch of these species usually accounts for aboutercent of the total. Various flounders are contribute most among the other species.

Hokkaido, south;

Alaska pollack usually account for about 70 percent and various flounders about 5 percent.

Pacific, north;

Alaska pollack accounts for about 50 percent followed by flounders (10 percent), cods (8 percent) rockfish (3 percent) and squids (6 percent).

Pacific, central and south;

Filefish dominate with about 28 percent, followed by lizardfish (7 percent) and squids (6 percent).

Table 3. Annual catch of demersal fish per unit area (1 km^2) of continental shelf (shallower than 200 m) by sea and region around Japan 1/.

(ton)

Sea and region (north to south) 2/	Total demersal fish catch catch per unit shelf area
Pacific Ocean	
Hokkaido, northeast	22.7
Hokkaido, south	12.9
Pacific, north	6.4
Pacific, central	5.2
Pacific, south	2.7
Japan Sea	
Hokkaido, west	9.7
Japan Sea, north	3.0
Japan Sea, south	3.2
East China Sea	0.4
Seto Inland Sea	9.6
Overall average 3/	3.9

1/ Calculated from the largest catch reported from 1968 to 1977.

2/ See Figure 1 for the regions.

3/ Does not cover the whole of the Japanese coast as the waters along the East China Sea coast (west of Kyushu) are not included.

4.2.2 Japan Sea (see Figure 1 for the region)

Hokkaido, west;

The combined catch of Atka mackerel and Alaska pollack accounts for about 88 percent.

Japan Sea, north;

The four major species accounts for about a half of the total catch; these are Atka mackerel (17 percent), Japanese argentine (12 percent), Japanese sandfish (10 percent), and Alaska pollack (10 percent). Various flounders (16 percent), Pacific cod (6 percent), northern shrimp (5 percent), tanner crab (5 percent) and spiny dogfish (4 percent) follow among the rest.

Japan Sea, west;

Squids (17 percent), Japanese roundnose flounder ("mushi-garei", 14 percent), Sohachi flounder (5 percent) and Japanese argentine (5 percent) are the major species included in the catch. The rest of the catch (about 60 percent) is composed of a variety of species.

4.3 Fisheries and Management

The fisheries harvesting these species are multi-gear fisheries. The gear includes various types of trawl, bottom longlines and gillnets, angling, boat seines, pots, traps and setnets. However, about 70 percent of the total demersal fish catch has been taken by trawls, and the rest (about 30 percent) by a variety of other types of gear. It should also be noted that mechanized trawls have been prohibited entirely in the nearshore waters, as have medium-type offshore trawls in the shallower part of the coastal zone (see Section 2).

The component of the catch taken by trawlers is larger in the north than in the south. It is largest in the waters around Hokkaido, with about 80 percent and decreases toward the south, especially along the Pacific coast. It is down to about 50 percent in the southern region. In the Japan Sea, however, the difference is moderate with about 57 percent in the north and 45 percent in the south. Table 4 shows the figures in more detail.

As discussed previously most of the catch taken from the northern region is composed of a few species of low commercial value, while the catch from the southern region comprises a variety of species of high commercial value although the quantity of each is small compared to the northern species. These facts indicate that the demersal fish species of high commercial value are caught more selectively by various types of small-scale bottom gear rather than by trawls in the southern regions.

In other words, the coastal demersal fisheries around Japan are grouped into two different categories. They are (i) the fisheries aiming at a large quantity of fish of low commercial value, mostly using highly efficient trawls in the northern region and (ii) the fisheries pursuing a small quantity of fish of high commercial value with various kinds of small-scale gear in the southern and western regions. This is a result of the adaptation of the fisheries to natural conditions during a long period of development, i.e. difference in (a) the structure of the fish community, (b) the abundance of stocks and (c) the availability of fish to specific kinds of gear in particular regions.

Table 4. Total demersal fish catch by region and the proportion taken by trawlers, 1976.

Sea, region and (sub-region) 1/	Total catch (000 t)	Trawl catch (000 t)	Proportion of trawl catch (%)
Pacific Ocean	1 334	995	75
Hokkaido, combined	1 045	822	79
Hokkaido, northeast	605	544	90
Hokkaido, south	270	180	67
Pacific, combined	289	173	60
Pacific, north	180	115	64
Pacific, central	75	41	54
Pacific, south	34	17	51
(Kagoshima 2/)	(9)	(2)	(23)
(Okinawa 3/)	(5)	(-)	(0)
Japan Sea	434	216	50
Hokkaido, west	169	96	57
Japan Sea, north	79	37	47
Japan Sea, south	186	83	45
Seto Inland Sea	186	103	55
Overall average 4/	1 954	1 314	67

1/ See Figure 1 for the location of the regions.

2/ Southernmost prefecture of Kyushu.

3/ Prefecture covering the Ryukyu Islands, southwestern-most prefecture of Japan.

4/ Does not cover the whole of the Japanese coast as the waters along the East China Sea coast (west of Kyushu) are not included.

However, it should be noted that fisheries management in Japan has also arranged to support and maintain this adaptation of the fisheries to various local conditions. For instance, licences for the medium-type one-boat offshore trawling, (the minister-licensed fishery, see Section 2 and Table 2), have been granted more often in the northern region than in the south, especially along the Pacific coast.1/ On the other hand, more licences for small-scale trawling, the governor-licensed but nationally registered fishery (see Section 2 and Table 2), have been granted in waters where the prime target species of small trawlers are abundant, e.g. prawns, shrimps, clams, sea cucumbers and various coastal finfish, regardless of the geographic location of the waters. For instance, about 11 300 (43 percent) small trawlers were licensed in the Seto Inland Sea out of the total number of 26 400 vessels licensed for the entire coastal waters around Japan. The case of the Seto Inland Sea will be discussed in further detail in Section 6.

The principle employed in the management of demersal fish fisheries and resources is the same as that for all the fisheries and resources around Japan, namely, the limitation of total fishing intensity as was discussed previously (see Section 2). Generally speaking, the management measures based on an analytical model (e.g. a catch-quota system derived from a yield-per-recruit model) are theoretically applicable to demersal fish stocks. In Japan, however, this type of approach has been little employed because of the extreme difficulties involved in practical application, especially as regards surveillance and enforcement (see Subsection 2.2).

It is often said that the management by control of the total fishing intensity tends to be too late, for conservation and management purposes, to cope with changes in stock abundance. In fact, even in Japan some stocks were depleted by overfishing during the early development of the fisheries in the 1950's and 60's. Both the the catch rate and total catch declined seriously with a large decrease in fish size/age, which resulted in a large loss of net revenue for the fishermen concerned (e.g. some rockfish and flounders in the northern region, red sea bream and bastard halibut in the southern region).

However, some of them had already recovered by the time comprehensive regulatory measures covered the entire region, and others have been recovering in recent years too, although full recovery from the initial decline has taken 10 to 15 years. It should be noted, that the abundance of some stocks that have recovered in recent years far exceeds what it was at the initial stage of the development of the fisheries (e.g. bastard halibut). During the past 15 years, no serious deterioration of stock or drastic change in species composition caused by overfishing has been experienced in the coastal demersal fish resources around Japan. The sequence of events experienced in the Seto Inland Sea will be described in Section 6.

Besides the management scheme employed, a region-specific feature involved in the exploitation of demersal fish resources is that almost the entire distribution range of the fish has been intensively utilized for fishing in some way. As seen in the previous subsection, nearshore waters, where spawning and nursery grounds of many demersal fish species are located, have been utilized intensively by numerous small fishing communities along the coast. This feature of Japanese demersal fish fisheries distinguishes them from trawl fisheries in other advanced fishing countries of the world where the trawlers depend mostly on the offshore distribution of the target species, e.g. the Northwest and Northeast Atlantic Oceans or the Northeast Pacific Ocean.

1/ 258 offshore trawlers (86 percent) were licensed for the waters along the Okhotsk Sea and Pacific coasts of Hokkaido and northern Honshu out of a total number of 301 licensed for the entire Pacific coast of Japan in 1985.

In Japan, therefore, the management of coastal demersal fish resources needs to cover the entire region and a variety of fisheries. A single measure or a simple scheme directed at a specific fishery (e.g. trawl or bottom long-line) does not work well. This is one of the reasons why the licensing/granting scheme in Japan has been so strict in specifying which fisheries may operate in each of the nearshore and offshore zones (see Section 2, Tables 1 and 2). For the same reason, various regulatory measures for conservation purposes have been designed to complement each other and cover the entire distribution range and life cycle of the target resources.

In other words, management of coastal demersal fish resources in Japan has been achieved by a multi-layered structure of regulatory measures applying in different circumstances (i.e. topographic, oceanographic, biological and fisheries conditions). This is another feature that distinguishes these fisheries from demersal fish fisheries in many developing countries, where the entire distribution range of resources has been utilized by various types of fishing gear, as in Japan, but comprehensive management has not yet been applied.

In addition to the legal arrangements made by both the central and local governments, the co-ordination of effort and co-operation between fishermen have undoubtedly contributed to the harmonious utilization of resources and the enforcement of management measures in the demersal fish fisheries (see Sections 2 and 6).

5. COASTAL PELAGIC FISH FISHERIES AROUND JAPAN

The majority of coastal pelagic fish resources distributed in the waters around Japan are composed of nine major species. They include Japanese sardine, Japanese anchovy, Japanese chub mackerel,1/ Japanese Jack mackerel, Pacific saury, Japanese amberjack (yellowtail), Japanese Spanish mackerel, Japanese flying squid and Japanese round herring.2/ An overall review of the biological features of these species and their fisheries have already been well documented in other papers (Nagasaki, 1973, Chikuni, 1985, Yamanaka et al., 1988). The authors therefore discuss here a few important features closely related to the management of multispecies pelagic fish resources in the region.

The above-mentioned nine species can be divided into two groups: (1) the species of small size with a short lifespan and planktivorous to omnivorous food habits and (2) the species of larger size with a comparatively long lifespan and omnivorous to piscivorous food habits. Sardine, anchovy, chub

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1/ Strictly speaking, nominal catch statistics include the catch of a small amount of spotted chub mackerel, Scomber australasicus Cuvier, due to the difficulty in separating the species on board. They account for about 5 percent of the chub mackerel catch in the northern waters and about 15-25 percent in the southern waters.

2/ From the long-term point of view, Pacific herring is also one of the major coastal pelagic fish species of the region. From about 1910 to the early 1930's, herring predominated in northern waters of the region with annual catch of 500 to 700 000 tons, but these declined drastically during the 1940's and 50's. Recent annual catches remain low at several thousands tons only, this phenomenon being the complete reverse of what happened to Japanese sardine. It is possible that herring stocks will make a remarkable recovery in the future to become a part of major coastal pelagic fish resources in the region, as was the case with sardine. However, the authors exclude Pacific herring from discussion in this paper to focus on topics of current concern.

mackerel, Jack mackerel, saury, flying squid and round herring make up the first group, and amberjack and Spanish mackerel in the second.1/

5.1 Small Pelagic Fish

5.1.1 Biological features

The distribution ranges and major habitats of the fish in the first group generally overlap, as do some of their spawning grounds and seasons. There is undoubtedly, therefore, severe competition among these species for common requisition. For instance, competition for food during both larval and adult stages and for space among adults must be common. Even predacity among them by omnivorous species has been frequently reported, e.g. (i) flying squid feeding on sardine, anchovy, Jack mackerel and saury, (ii) adult chub mackerel on juvenile sardine and anchovy, (iii) adult Jack mackerel on juvenile sardine and anchovy, etc. In addition, all the species in this group are important food items for the larger omnivorous and piscivorous pelagic species, i.e. amberjack and Spanish mackerel. They therefore form a highly complicated multispecies fish community in the upper layer of the sea in the region.2/

Another distinguishable feature of the fish of this group is large fluctuations in stock abundance. The exact causes of this fluctuation are not yet known. However, scientists specializing in the subject recently agreed

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1/ (i) Skipjack tuna migrating annually into the coastal waters along the Pacific coast of Japan from early summer to autumn can also be placed in the latter group. Skipjack tuna are distributed widely in the Pacific Ocean beyond the region and are highly migratory fish. However, a large number of schools that migrate to the region to feed play a highly significant role in the predatory loss of coastal pelagic fish in the area, especially from the first group mentioned above. It is, therefore, an important element in the multi-species pelagic fish community in the region from a biological point of view. However, the authors exclude skipjack tuna from discussion here, as the management of skipjack tuna stocks raises issues that are beyond the framework of this paper.

(ii) Japanese sea bass has also acquired a pelagic nature, being caught by various kinds of surface gear including gillnets, setnets, purse seines, boat seines, hook-and-lines, etc. The fish can not, however, really be dealt with as a pelagic fish since it has a eurybath nature, while the trawl catch usually accounts for only 10-15 percent of the total. Sea bass is a highly neritic and sedentary fish inhabiting southern waters but a few biological features resemble those of Spanish mackerel or skipjack tuna, e.g. long lifespan and high trophic level. Stocks in the Seto Inland Sea will be discussed separately in a later section of this paper (see Subsection 6.3.3).

2/ Anchovy has a eurybath nature, inhabiting the sea from the surface to the bottom layer. Plenty of anchovy are found in the stomach contents of piscivorous and omnivorous demersal fish. The predatory loss of anchovy must therefore be quite large, since it is eaten by both pelagic and benthic predators. In fact, it has been estimated that the predatory loss of anchovy off the southern Pacific coast of Honshu far exceeds the catch taken by anchovy fisheries (Chikuni, 1985). Anchovy has acquired, therefore, a highly complicated multispecies nature not comparable with most other pelagic fish communities.

that the causes are mostly natural rather than to do with fishing (Csirke et al., 1984, Chikuni, 1985), and fluctuation in the survival rate for natural reasons during the early life stage of the fish is assumed to be one of the critical factors.

The natural mortality of these species during the early life stage is extremely high. For example, in sardine stock about 70 percent of eggs spawned are estimated to die during two- to three-day period before hatching, and about 96.5 percent of larvae hatched are lost during the 2 weeks before they reach the early post-larval stage at 17 mm body length. The total loss by the end of the post-larval stage (35 mm), 58 days after hatching, reaches about 99.93 percent. These figures are typical for pelagic fish, losses at the end of the post-larval stage being 99.9958 percent for chub mackerel, 99.9 percent for anchovy and 99.95 percent for amberjack. A change, even if a slight, in the natural mortality rate of these fish during their early life stages would therefore greatly affect first the magnitude of recruitment of the year-class born, and ultimately the total biomass of the entire stock in question.

The highly complicated oceanographic features of the region, which is prominent among the world's oceans, generally provides extremely favourable conditions for living resources, resulting in the formation of one of the most productive fishing grounds in the world (Nasu, 1975, Chikuni, 1985, Yamanaka, et al., 1988). On the other hand, changes in environmental conditions sometimes greatly affect the abundance of stock in both positive and negative ways. For instance, (i) the success or failure in spawning, embryonic development and/or hatching, (ii) magnitude of dispersion or concentration of eggs and larvae, (iii) the likelihood of finding enough suitable food at the critical stage (beginning of post-larval stage), and (iv) the likelihood of becoming the prey of other animals, including carnivorous zooplanktons are determined chiefly by environmental conditions. A change in one or a combination of these factors could result in a substantial change in the early survival (or mortality) rate (Chikuni, 1985).

Changes in stock abundance have led to large fluctuation in the catch of each species, except those of anchovy and round herring. Figure 4 shows the fluctuations observed for each from 1957 to 1981.

Japanese anchovy is the only species in this group which had not shown a drastic increase or decrease in its biomass over the years. It is assumed that the tolerant/resistant nature of the fish to (i) changes in the environment and (ii) large mortality (by predacity and heavy fishing) prevent large and rapid changes in its stock abundance (Chikuni, 1985). In the case of round herring too, species-specific biological features must have played an important role in keeping stock levels fairly stable (e.g. many small and separated local stocks confined to the southern region), although the details are not yet understood.

Pacific saury shows frequent short-term fluctuations with a one- to three-year interval, which may be more a result of annual changes in the catchability of fish schools than the changes in stock abundance (Chikuni, 1985).1/ However, a long-term change in stock abundance has been observed separately, which may have been caused by natural factors similar to those affecting other coastal pelagic fish.

1/ Similar fluctuations can be observed in the annual catch of skipjack tuna in coastal waters along northeast Honshu. Again, the explanation may have more to do with the catchability of the fish schools (pole-and-line fishing is used) rather than with annual changes in exploitable stock biomass.

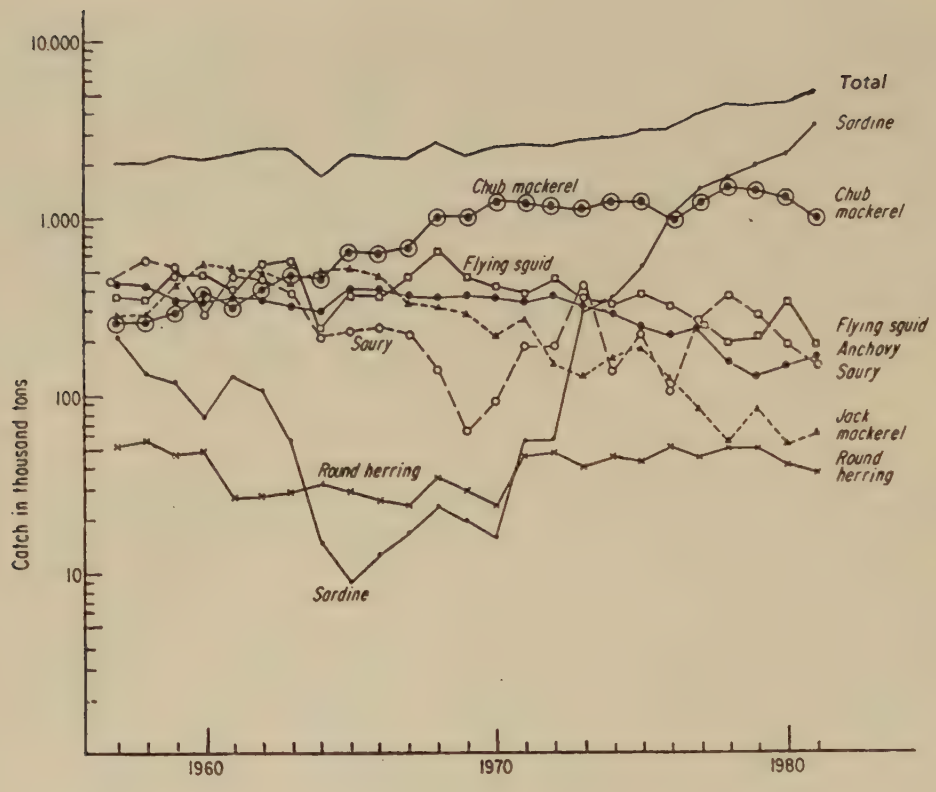

Figure 4. Annual change in the catch of major coastal small pelagic fish taken from the waters around Japan from 1957 to 1981 (Nagasaki, 1983).

Large changes in the catches of sardine, chub mackerel, Jack mackerel and flying squid are undoubtedly caused by fluctuations in stock abundance. Japanese sardine is the most extreme example. However, it is interesting to see that the total catch of this group (seven species combined) has shown a fairly stable trend over the years under review (see Figure 4). It can be seen that (i) a substantial increase in the catch of Jack mackerel from the mid-1950's to the mid-60's accompanied a large decline in that of sardine, (ii) a large increase in chub mackerel during the mid-1960's accompanied a sharp decline in Jack mackerel and a gradual decline in saury, and (iii) the recent rapid increase in the sardine catch since 1973 accompanied the further decline in Jack mackerel, and a gradual decline in catches of anchovy and flying squid.

The processes responsible for these changes are not yet understood. However, it is clear that the species composition of the pelagic fish community in the region is always changing dynamically, with dominance switching from one species to another (possibly through both the density-dependent and independent natural factors), which has compelled the fishermen to change their target species from one to another. In other words, the coastal pelagic fish fisheries in Japan have survived as a whole by employing flexible fishing over the years.1/

The total catch of Japanese sardine from the entire Northwest Pacific in 1985 was about 4.72 million tons, of which about 82 percent was taken by Japanese fisheries from the waters around Japan. This was the third largest single-species catch among the world's oceans, preceded only by the South American pilchard in the Southeast Pacific (5.81 million tons) and Alaska pollack in the Northeast Pacific (4.73 million tons). However, it is quite likely that the catch will decline again in the future, as a result of a decline in stock abundance caused by natural reasons, as has been experienced in the past. The catch was only about 9 000 tons from the entire Northwest Pacific in 1965, which is less than 0.2 percent of the current catch.

It is interesting to note the stable trend of the total catch (seven major pelagic species combined) as compared with fluctuations in catches for particular species. It is noticeable that even around 1965, which was the worst period for sardine stock, the lack of sardine production was offset by the production of other species, e.g. chub mackerel, Jack mackerel, saury and flying squid (see Figure 4). This is an important point that must be taken into account when a management scheme is established for coastal pelagic fish resources in a region as a whole.

5.1.2 Fisheries and management

Although small coastal pelagic fish in the region form a complicated multispecies resource, the fisheries harvesting these fish are simply structured compared with those for demersal multispecies resources, for which multi-gear fisheries are commonly employed. This is because of the species-specific availability of the fish to a specific gear/method, based on distribution and migratory pattern, shoaling and swarming nature, body shape, phototaxis, and feeding habits, etc. These features have determined the specific fishing method/gear for each of the target species. Table 5 shows the combination of the two.

1/ The Japanese fisheries have so far experienced two extreme cases that almost caused the collapse of specific fisheries. These were the Pacific herring setnet fishery along the Hokkaido coast and the Japanese sardine fishery (purse seines, setnets and gillnets) all along the Japanese coast (see footnote 2/ in this Section).

Table 5. Catch of major pelagic fish species by fishing gear taken from the waters around Japan in 1985.

('000 t)

Fisheries	Species	Japanese sardine	Japanese anchovy	"Shirasu"	Japanese chub mackerel	Japanese Jack mackerel
Large/medium type purse seine (one and two boats)		2 778	6	–	541	85
Medium/small type purse seine (one and two boats)		707	92	–	133	51
Boat seine		53	89	94	1	1
Saury stick-held dipnet		0	–	–	0	–
Other dipnet		8	5	1	49	2
Squid jigging		0	–	–	–	0
Other angling		–	–	–	10	3
Gillnet		1	0	–	0	0
Setnet		232	13	0	24	9
Beach seine		1	0	0	0	0
Trawl (various)		0	0	0	0	0
Other gears		87	1	0	13	7
Total 2/		3 866	206	95	771	158

continued...

Fisheries	Pacific saury	Japanese flying squid	Round herring	Japanese amberjack	Japanese Spanish mackerel	Total 1/
Large/medium type purse seine (one and two boats)	–	–	4	0	0	3 414
Medium/small type purse seine (one and two boats)	–	–	16	9	0	1 008
Boat seine	0	0	0	0	0	238
Saury stick-held dipnet	242	0	–	–	–	242
Other dipnet	0	0	8	0	0	73
Squid jigging	–	122	0	–	0	122
Other angling	0	0	0	7	3	23
Gillnet	1	0	0	5	4	11
Setnet	3	6	3	12	2	304
Beach seine	0	0	0	0	0	1
Trawl (various)	–	4	–	0	1	5
Other gears	0	1	0	0	0	109
Total 2/	246	133	30	33	11	5 549

1/ Sum of the listed species, not total catch by fishery.

2/ Total catch by species taken by all the fisheries.

(a) Pacific saury and Japanese flying squid

As shown in Table 5, saury and flying squid have been caught almost exclusively by a single gear fishery for each, namely, stick-held dipnet for the former species and mechanized jigging for the latter. Both use luring lights, taking advantage of strong phototaxis and the swarming nature of the fish.1/ In the case of flying squid, their greedy feeding habits also facilitate the jigging with artificial bait. Both are minister-approved fisheries, for which licences are granted on a national basis (see Section 2 and Table 2), but the management applied to these fisheries works on the basis that each is a single-species fishery.

b) Japanese anchovy

Japanese anchovy has been caught mostly by medium/small purse seines and boat seines, and partly by setnets (Table 5). These fisheries are all governor-licensed fisheries. However, medium-size purse seine (all over the coast) and boat seine in the Seto Inland Sea are nationally registered fisheries for which the governor of each prefecture can issue licences within the limits set by the minister (see Section 2 and Table 2). They generally operate fishing almost exclusively for anchovy although the licences allow the fishermen to fish other species in some circumstances. The more severe regulations employed in the Seto Inland Sea aim to ensure harmonious operations in a relatively small and closed area of the sea (see Section 6 for details). The setnet fishery is one of the fishing right fisheries, which are subject to further strict regulations, as discussed in Section 2.

A particular feature of the exploitation of anchovy in Japan is that the post-larvae (15-35 mm body length) and younger juveniles (35-50 mm) have been intensively harvested by the specialized boat seines that make up the "shirasu" fishery, strictly defined and subject to further regulations.2/ This implies that the high reproductive potential of anchovy does not require severe regulation on catching small-size, immature fish (Chikuni, 1985).

(c) Japanese sardine, Japanese chub mackerel and Japanese Jack mackerel

The majority of the catch of the other three major pelagic fish, sardine, chub mackerel and Jack mackerel, have been caught mostly by purse seine. The fisheries are composed of large/medium and medium/small types of both one- and two-boat purse seines. The combined catch of the three species taken by these two fisheries accounts for about 77 percent of the total coastal pelagic fish catch. These fisheries are therefore characterized by being directed at a massive catch of species of low commercial value, resembling the offshore trawl fisheries in the northern region (see Section 4). This tendency can be seen more clearly with larger purse seines, whose catch of these three species accounts for more than 99 percent of the total coastal pelagic fish taken by that

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1/ Before the early 1950's saury was fished mostly by drift gillnet without luring lights, and flying squid by pole-and-line and handline with lights. However, the monospecies nature of the fishing was the same.

2/ The annual catch of "shirasu", amounting to 60-90 000 tons, accounts for about 30 percent of total anchovy production by weight. However, the actual number of these taken is about ten times greater than that of the adult fish caught by the anchovy fishery (Chikuni, 1985).

means, while more than 10 percent of the total catch of smaller purse seines is composed of other fish including anchovy, round herring and amberjack (see Table 5).

The large/medium-type purse seine fishery (with vessels larger than 40 gross tons) is licensed by minister on a national basis (see Section 2 and Table 2). The number of vessels licensed is limited by sea area, within a total allowable number for the entire region: 377, of which 328 vessels actually operated in 1985 (304 one-boat and 24 two-boat seines). The maximum size of a vessel is also limited to 135 gross tons. The shallower zones of coastal waters around Japan are generally closed to the fishery to prevent conflicts with small-scale fisheries.

The medium-type purse seine fishery (with vessels of 5-40 gross tons) is licensed by local governor within the limit of the number of vessels1/ allocated to each of the prefectures by the minister (see Section 2 and Table 2). The total number of vessels licensed for the entire region in 1985 was 968, of which 778 actually operated.

Small purse seines (smaller than 5 gross tons) are licensed by the prefectural governor on a completely local basis. In 1985 about 1 000 vessels actually operated, fishing not only for the major coastal pelagic fish but also for other coastal pelagic fish including dolphin fish, Japanese flying fish and flathead mullet, etc.

From a legal point of view, there is no strict limitation on selecting a target fish species. The fishermen can therefore decide their fishing strategy on their own, which enables them to switch from one type of fishing to another according to the change in catchability or profitability of the fish. Operations, though, are subject to coordination and agreement with the fisheries cooperatives into which the fishermen are organized. This is an important factor to be taken into account for management purposes, which results in evening out the long-term trend of total pelagic fish catch in spite of the large and infinite changes in the abundance of different fish stocks and species composition of the fish community (see Figure 4). It should be noted that the management scheme employed in these fisheries is unable to regulate a single species catch separately from the combined fish catch, unless a sophisticated catch-quota system is enforced, which has not been adopted in Japan for practical reasons (see Section 2).

For stocks like sardine, chub or Jack mackerels, the yield curve against the fishing intensity generally becomes flat-topped beyond a certain level of fishing intensity, which is quite different from those for many demersal fish stocks, for which yield declines beyond an optimum level of fishing. This suggests a few important points for management of these fisheries: (i) when stock abundance is growing or at a very high level, reduction in fishing intensity does not result in a increase in total fisheries production; however, (ii) the catch rate (catch per unit effort) decreases (or increases) according to the increase (or decrease) of fishing intensity in such a phase; (iii) the optimum level of fishing is therefore decided mostly from an economic or social rather than a biological point of view; however, (iv) if the stock begins to decline for some natural reasons, the stock abundance and yield would continue to decline even if fishing intensity is reduced, (v) it would further decline precipitously if fishing intensity is increased or not reduced in such a situation (Chikuni, 1985).

1/ The limit is generally defined by triple limitations: (i) total number of vessels, (ii) total gross tonnage and/or (iii) total engine power of all vessels.

There may be no need to impose strict regulation when stock is growing and/or very abundant. A fisheries forecasting service, if employed, would greatly facilitate the effective use of these resources in such situations (Chikuni, 1985, Yamanaka, et al. 1988). The forecasting service would also contribute a great deal to monitor the current status and to predict the probable future change of a specific stock.

Cautious fishing, however, is needed when the stock is declining. Probably an immediate reaction from the stock in question cannot be expected even if fishing intensity is substantially reduced, since no clear reversible relationship has been observed between stock abundance and fishing intensity as seen above. However, care should be taken to allow stock to maintain a certain level of reproductive potential (spawning magnitude) so that it can recover when favourable conditions arise during periods of decline or depletion. Even in this case a fisheries forecasting service would make a contribution, first by helping to achieve cautious fishing and second by helping the fisheries to stabilize by shifting target species (Chikuni, 1985, Yamanaka, 1988).

5.2 Larger Pelagic Fish

Japanese amberjack (yellowtail) and Japanese Spanish mackerel are included in this group. Both has acquired a higher trophic level in a fish community with omnivorous to piscivorous feeding habits.1/ The fish therefore behave as predators in the pelagic fish community, feeding intensively on sardine, chub and Jack mackerels, saury and flying squid, especially during their juvenile and adult stages. They are generally caught by gears specially directed at them, e.g. amberjack or Spanish mackerel gillnet, hook-and-line (troll) and setnet, etc. (see Table 5).

Amberjack was caught almost exclusively by setnet until the late 1950's. However, the catch using other gears (hook-and-lines, purse seines and gillnets) has gradually increased thereafter as the setnet catch has gradually declined. The recent catch by the other four types of gear far exceeds that by setnets (i.e. setnets, 12 000 tons: purse seine, 9 000 tons: angling, 7 000 tons: gillnets, 5 000 tons: for a total of about 33 500 tons in 1985). This has probably been caused by a change in the availability of the fish, especially to the setnet, while abundance and the total catch from the waters around Japan appear to have remained stable over the years (Chikuni, 1985).

A peculiar feature of the exploitation of amberjack in Japan is the quantity of fry and juveniles collected alive to be used as seedfish for aquaculture. The total number of seedfish supplied annually for aquaculture has been about 70-80 million in recent years, and the total annual production of aquaculture is about 150 to 155 000 tons, which is about 4.5 times that of the current catch of natural fish. However, no negative effect has been observed so far on natural stock abundance (Chikuni, 1985).

Spanish mackerel has been caught by various types of gear including gillnets, trolls, handlines and setnets, mostly along the southern coast of Japan. The catch taken in the Seto Inland Sea has been large, usually accounting for more than 50 percent of the total catch - (6 000 tons out of 11 000 tons in 1985), but this will be discussed in further detail in Section 6 of this paper.

1/ See Footnote 3/ (ii) of this section for some observations on the classification of Japanese sea bass, and Section 6 for details of the stock in the Seto Inland Sea.

The fisheries exploiting these two species are mostly of small scale, except for large-scale amberjack setnets in the fishing right-fishery, and all are categorized as governor-licensed fisheries (see Tables 2 and 5). The principles employed in licensing and managing these fisheries are those of a single species for each, again with the exception of amberjack setnets because of its large amount of by-catch of other species.

It is interesting to note the stable trend of the total catch (seven major pelagic species combined) as compared with fluctuations in catches for particular species. It is noticeable that even around 1965, which was the worst period for sardine stock, the lack of sardine production was offset by the production of other species, e.g. chub mackerel, Jack mackerel, saury and flying squid (see Figure 4). This is an important point that must be taken into account when a management scheme is established for coastal pelagic fish resources in a region as a whole.

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6. COMPREHENSIVE RESOURCES UTILIZATION: THE SETO INLAND SEA

6.1 General Features

The Seto Inland Sea is a small, shallow and closed sea located in the southwestern part of Japan. It is connected to the outer seas by three channels: the Kii Channel in the east and the Bungo Channel in the southwest linking it to the Pacific Ocean, and the Kanmon Channel in the west linking it To the Japan Sea (see Figure 5). The inflow through the first two channels of the warm waters originating from the Kuroshio greatly affects the oceanographic conditions of the sea, but the influence of the two differs, dividing the sea into two subregions, the east and the west (Figure 5). However, the inflow of waters from the Japan Sea is locally limited to the westernmost part of the sea owing to the very narrow topography of the Kanmon Channel.

The entire area is about 18 700 km^2 with a mean depth of 33 m and a total water volume of about 610 km^3. The sea is characterized first by its temperate nature, being influenced by the Kuroshio, and second by its highly neritic nature, a result of its topography and large effluents from numerous rivers along the coast. These characteristics have created a unique and highly productive complex of living resources.

More than 3 000 species of aquatic animals and about 500 species of aquatic plants inhabit the sea. The number of species of commercial value exceeds 200. A distinctive characteristic of the living resources in the sea is that no species predominates by its biomass, except Japanese anchovy. This results in the formation of a unique, exploitable fish community as a complex of various species of small biomass. The annual catch of anchovy (including that of "shirasu") usually accounts for about 35 to 40 percent of the total fish catch, which shows the highly neritic nature of the sea on one hand and suggests a plentiful supply of prey for carnivorous fish on the other.

The fish caught in the sea can be classified into three groups according to their life form. These are (i) those that migrate into the sea for spawning and move out to their major habitat in outer seas during the rest of the year,1/ (ii) those that spawn in the outer seas and migrate into the sea seasonally or at sometime in their life stage and (iii) those whose entire life cycle occurs in the sea. The first group includes red sea bream and Japanese Spanish mackerel; the second, Japanese amberjack, Japanese sardine, Japanese chub mackerel and Japanese Jack mackerel;2/ and the third, various sedentary species, e.g. flounders, soles, rockfish, croakers, largehead hairtail, lizardfish, Japanese sea bass, grunters, gurnards, pony fish, sandlance, etc.3/

Prawns/shrimps, cephalopods, and most of the other animals are sedentary species. Prawns and shrimps are one of the most important species groups to the fisheries in the area as the total catch taken from the sea usually accounts for about 40-50 percent of the total shrimp catch from the entire Japanese coast. Major species include kuruma prawn, green tiger prawn, shiba shrimp, tora velvet shrimp, whiskered velvet shrimp, moebi shrimp and southern rough shrimp.4/

6.2 Fisheries and Management

The fisheries in the Seto Inland Sea are all of small scale, being composed of various multi-gear fisheries. Although the principles of the management employed in the region are the same as those for all the coastal waters around Japan (see Section 2), the limitations and the regulations imposed on the fisheries in the sea are the most specific and the most strict. This is a result first of the enormous value of the sea not only to the fisheries but also to the nation, second of the comparatively large production

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1/ The larvae, fry and juveniles of these fish develop in the nursery grounds in the sea throughout the year. They usually emigrate to outer seas after they mature, but some local stocks remain in the sea throughout their life.

2/ Some sardine, chub and Jack mackerels spawn in the sea, but do not complete their life cycle as an independent sedentary local stock.

3/ Some species may move to and from outer seas, especially to and from the waters along the Pacific coast of Japan through the two channels mentioned above, e.g. Japanese sea bass, lizardfish, croakers, largehead hairtail, etc. However, a regular or massive migratory pattern is not generally observed for these species.

4/ All are FAO defined names (Holthius, 1980).

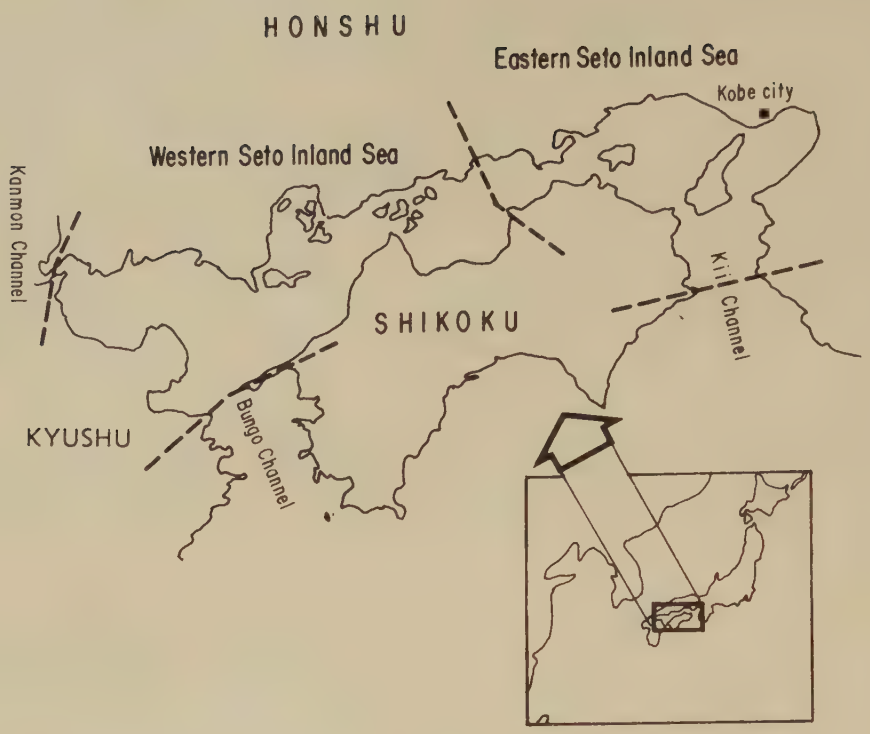

Figure 5. The topography and subregions of the Seto Inland Sea referred to in this paper (Tatara, 1981, 1981a, modified by the authors).

of fish 1/ from a narrow and shallow sea area with high fishing populations along the coast, and third of special requirements for conservation related to topography and biological diversity of the sea where spawning, nursery and fishing grounds are all distributed in a narrow sea area.

The flexibility of the fishermen in changing their fishing from one species to another is another distinctive feature of the fisheries here although this type of fishing is by now practiced by almost all coastal fishermen in Japan. Strict regulation and flexible fishing appear superficially to be antipathetical but they actually supplement and support each other, a fact that will be discussed in detail in the later part of this subsection. The region-specific measures currently employed are summarized as follows.

1/ The quantity of the total catch means high economic return for fishermen. The catch has been boosted by the favourable natural environment, which will be discussed in later parts of this section, and fishermen have benefited from the advantageous geographic location of the sea, which has easy access to a number of large wholesale markets in urban districts along the coast.

6.2.1 Major region-specific regulations (see Table 2)

a) All the large- to medium-size fisheries, subject to licence by the minister, are prohibited (trawl, purse seine, boat seine, etc.)

b) The number of medium-type boat seines, specifically defined as the Seto Inland Sea Boat Seine Fishery (5-15 gross tons), in each of the prefectures is nationally limited by the minister.

c) Mechanized trawl larger than 5 gross tons is prohibited, and the number of those smaller than 5 gross tons (specifically defined as the Seto Inland Sea Small Mechanized Trawl Fishery) in each prefecture is nationally limited by the minister.

d) The fishing methods of the trawl fishery mentioned above are permitted for one of the following: (i) trawl without any net-opening device, (ii) trawl with a beam, (iii) trawl with a frame (dredge-net), (iv) sailing trawl, and (v) others for which specifications and applicable sea area are defined separately.

e) Otter-trawl and two-boat trawl are prohibited. Beam trawl, dredge trawl and sailing trawl are permitted, but up to the total number mentioned above for each.

f) Acoustic fish finders and luring lights are prohibited, excluding particular fisheries in defined areas.

g) For various small-scale fisheries other than the above (vessels less than 5 gross tons) subject to the regulations defined by the prefectural governor, major regulations include:

limitation of total number of vessels by fishery,

permanent or seasonal closure of specific areas for conservation and coordination purposes,

mandatory seasonal lay-off of specific fisheries for conservation and coordination purposes,

mesh- and gear-size limitations,

body-size limitation (fish, clams, shrimps and lobsters),

prohibition of night fishing, excluding specific fisheries in defined areas.

6.2.2 Fisheries co-ordination

A well-designed co-ordinating scheme and appropriate enforcement are required for the fisheries in the sea owing to their highly complicated structure and the variety of fishing gear/methods involved. This has been achieved in two ways, as discussed previously: on the one hand through central and local governments, and on the other by fishermen themselves through various functions/ activities of fisheries cooperatives (see Section 2 for the legal arrangements and Section 3 for a practical example).

(1) Governmental arrangements

In addition to the actions taken directly by the minister or governors, the ministry has established a regional branch office, the Seto Inland Sea Fisheries Coordination Office, in Kobe, the capital of the Hyogo Prefecture located at the northeast coast of the sea (see Figure 5). The branch office is assigned the task of handling a part of (i) the co-ordination of the fisheries and (ii) the enforcement of conservation and management measures on site.

As the independent local authorities, fisheries co-ordinating committees have been established at two different levels in the region; there is a Sea Area Fisheries Coordination Committee in each of the prefectures bordering the sea (10 sea areas in total) and there is the Joint Seto Inland Sea Fisheries Coordination Committee. The committee members of the former represent the fishermen in each sea area (those elected by fishermen) and the public interest (those nominated by the governor). The members of the latter are composed of representatives from each of the sea-area committees (elected, usually the president of each sea area committee) and the experienced and knowledgeable men (nominated by the minister). The minister and the governor have to consult these committees when establishing new measures and modifying those currently employed, or dealing with disputes when they occur. All the fisheries co-operatives in the region are bound by the decisions made by these committees.

(2) Autonomous co-ordination and regulation by fisheries co-operatives

This is generally the same as that employed by all coastal fisheries co-operatives in Japan as discussed earlier part of this paper (see Section 2). In the Seto Inland Sea, however, characterized by its strong nearshore nature, the functions borne by cooperatives are the most important and effective, as seen in the example of the Hime-shima fisheries co-operative (see Subsection 3.1).

Co-ordination and regulation are mandatory and most strict in the fisheries included in the fishing-right fishery granted to fisheries co-operatives. This is because the details of management and co-ordination are legally entrusted to the co-operatives by the governor (see Section 2). However, fishing is usually co-ordinated not only within the framework of a fishing-right fishery or a licensed-fishery but for all fisheries, including aquaculture, in a entire coastal zone. This has been done either by single co-operatives in some cases or jointly by two or more co-operatives in others.

6.3 Historical Review

6.3.1 Development of fisheries and change in environment

(1) Gross production

The total catch, all species combined, taken annually from the sea has ranged from 420 to 480 000 tons during the past decade, which accounts for about 5.5 to 5.9 percent of the total catch from the entire coastal waters of Japan, and is a substantial quantity from a narrow sea area. The catch per unit sea area is therefore high for the coastal waters around Japan, especially for the southern regions, with about 21 to 26 tons/km^2.

However, the production was not so high before the mid 1940's (before the Second World War), with an annual total catch of about 120-150 000 tons, but the catch was composed more of species of high commercial value than catches in recent years, and these were taken by various types of small-scale fishing gear. Although the catch rate (catch per unit effort) for individual fishermen was maintained at a fairly high level during the pre-war period, conflicts between fishermen over the best fishing grounds for profitable species were common among those using both similar and dissimilar types of gear.

Many complaints by fishermen about over capacity or overfishing during these periods were therefore a result of competition and the pursuit of higher profits, but not of concern about the decline in biological productivity (modern concept). It should also be noted that the legal arrangements for fishing industry were all feudalistic and fisheries coordination was left entirely to traditional and old-fashioned ways in those days.

Fishing in the sea, having slackened off during the Second World War, resumed and rapidly developed after about 1950 as the industry and the national economy recovered. In the meantime, re-organization of the legal scheme for fisheries had been undertaken, and a modern legal system covering all Japanese fisheries was finally established during the late 1940's and the early 1950's (see Section 2). The new scheme is highly democratic in its philosophy and structure, but the tradition and customs commonly kept to by fishermen were fully taken into account when the scheme was formulated.

In these circumstances and to meet the strong demand for animal protein caused by the serious shortage of food in the aftermath of the war, the total catch increased rapidly from 1950-55 and reached about 240-250 000 tons. The total catch, which had levelled off for a few years after the big surge, rapidly increased again during the late 1960's and early 1970's up to a level of about 400 000 tons.

(2) Increase in biological productivity

The large increases in the total catch mentioned above were made possible by the overall recovery and development of the fisheries during those periods. However, the catch continued to increase even after the mid 1960's when the fisheries were considered to have reached maximum development in terms of the fishing grounds covered and fishing gears improved. Some changes favouring greater fisheries production may have occurred in the fish community in the sea, in addition to the increased fishing intensity.

Tatara (1981, 1981a) hypothesized, after examining biologically the two remarkable rises in the total catch mentioned above, that the enhancement of the sea's biological productivity took place in conjunction with the eutrophication of the waters during those periods. The enhancement meant first the greater capacity of the waters to support living resources (in terms of the nutrition available), second a larger biomass of fauna and flora, and ultimately higher catches for the fisheries. Figure 6 illustrates schematically Tatara's hypothesis (1981).

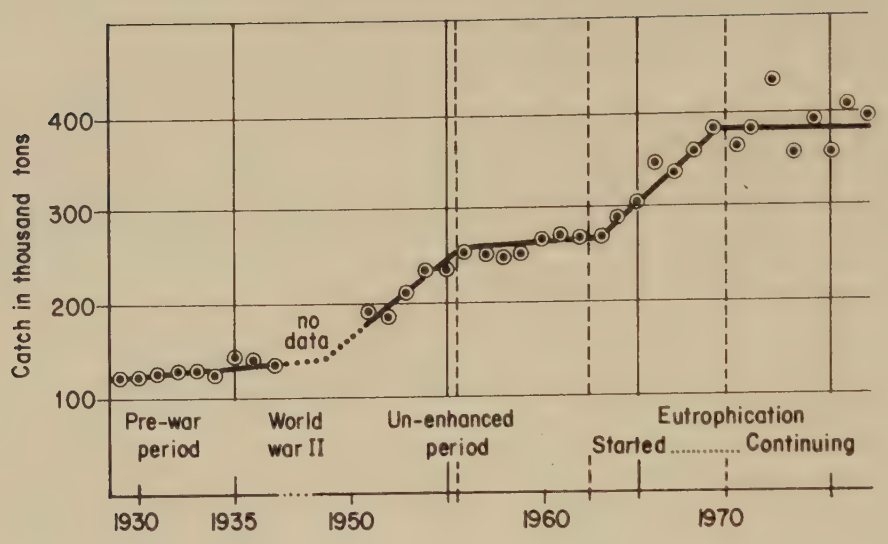

Figure 6. The annual total marine catch taken from the Seto Inland Sea from 1929 to 1976, together with indications on changes in the fisheries and their environment (Tatara, 1981, modified by the authors).

The hypothesis appears to be quite plausible as there is no doubt that nutritious effluents have substantially increased during these periods in accordance with rapid industrialization and the urbanization of the Seto Inland Sea coast. The nutritious enhancement, thus brought about, would have certainly facilitated greater primary production in the sea, resulting in larger populations of animals at higher trophic levels. The detritus and suspensions also might have been increased by a greater quantity of decomposers, which would have led to larger production of animals of lower trophic levels feeding on those items. It is likely that fishery resources in the sea would have been able to attain a larger biomass through this expansion of the ecosystem.

Thus, the total catch from the sea increased further beyond the maximum level of the development of fisheries at that time, although the implications of this assumption should be subject to further studies in the future. It implies, at the same time, that the structure of the ecosystem in the sea (species composition and inter-species functions) changed substantially during those periods, but this will be discussed in a later part of this section.

3) Side-effects of greater production

It should be noted, however, that various and serious side effects occurred during the initial stages of the rapid eutrophication. They were the pollution of sea water and the contamination of sea food. These problems occurred not only in the Seto Inland Sea but in almost all coastal waters around Japan. The public research institutes, fisheries, industrial and health administrations, worked hard for several years to establish new regulatory measures to control the environmental menace. The situation has much improved since a new regulatory scheme was established during the late 1960's.1/

Pollution caused by agricultural chemicals, not thought to be closely linked with the eutrophication of the sea, was also common from the late 1950's to the mid 60's, even though the Agricultural Chemicals Control Law had been in force since 1948. This was concerned with the wide use of various chemicals (insecticides, fungicides, weed killers, fertilizers, etc.) to increase farm crop productivity and quality as part of the process of rapid modernization of all agriculture during the period, e.g. cereals, root crops, vegetables, pulses, fruits, nuts, tea and tobacco. Although no information or data are available, the damage caused to marine life by this type of pollution is likely to be most serious during the early life stages of fish, as they are extremely fragile and generally inhabit the shallower areas of nearshore waters. The situation regarding visible damage and, it is assumed, invisible damage too, has improved greatly since new regulations were established in the early 1970's, especially on insecticides of the residual type (i.e. the Enforcement Act for Agricultural Chemicals Control Law, enacted in 1971).

In the Seto Inland Sea, special arrangements have been made, in addition to the basic general regulations, in view of the great value and the topographical uniqueness of the sea.2/ Thus, various strict regulations have been imposed since 1973 on all industries and local governments in the prefectures bordering the sea. It is not the main purpose of this paper to cover this subject in detail. However, a warning needs to be given here, because cases resembling that mentioned above are now becoming more and more common in the shallower parts of the coastal waters of many developing countries, especially in the tropics.

Apart from the direct man-made hazards mentioned above, a complicated side-effect has also accompanied the eutrophication of the sea. This is the occasional occurrence of the "red tide" caused by a burst and concentration of various phytoplanktons and zooplanktons in a limited sea area. The red tide, once occurs in coastal waters, sometimes seriously damages both the natural resources and aquaculture. Although the phenomenon can be observed in many coastal waters around Japan,

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1/ Four major laws are the core of the scheme: (i) the Primary Law on Public Menace Control (enacted in 1967), (ii)b the Water Pollution Protection Law (1970), (iii) the Disposal Treatment and Scavengery Law (1970), and (iv) the Ocean Pollution and Disaster Protection Law (1970).

2/ The Law on Special Measures for Environmental Protection of the Seto Inland Sea (enacted in 1973) defines wide ranging and strict regulations to be imposed on various industries and local governments for the protection of the entire sea environment, and includes regulations on water quality, the lie of land, the topography of shore, beach and seabed, and landscape.

especially in bays and inlets, it occurs most often and causes most damage in the Seto Inland Sea owing to the special topographic and oceanographic features, and presumably to its eutrophy. For instance, both the number of red tides and the amount of damage to the sea rapidly increased during the later 1960's, which coincided with the assumed completion of the first rapid eutrophication (see Figure 6). Thus, the fisheries research institutes and administrations initiated intensive research and took actions to establish appropriate counter-measures here too.

The great difficulty in handling red tide problems is the complexity and variability of their origins and effects. This is because many species of both phytoplankton and zooplankton are involved, environmental conditions promoting a sudden increase of particular types of plankton differ greatly, and their physiological influence upon animal life also differ from one case to another.1/ This is a completely different situation from that regarding pollution or contamination that can be effectively controlled if surveillance and enforcement of the regulations are adequate. The subject falls outside the scope of this paper and must be examined in detail in another paper. However, it should be noted here again, as a warning, that similar phenomena becoming common in many coastal waters in the developing countries, especially in the tropics. A review of various cases observed in Japanese waters, the current status of research, knowledge so far obtained, counter-measures being taken, the prediction and forecasting service, etc. are well documented by Hanaoka et al., (1980).

6.3.2 Global change in resources

The entire ecosystem of marine living organisms inhabiting the Seto Inland Sea can be divided into two subsystems according to their food-web. The energy flow of each is schematically illustrated as follows:

I. Piscivorous system

phytoplankton - zooplankton - fish - piscivorous fish

II. Omnivorous system

phytoplankton/detritus - zooplankton/benthos - invertebrates/fish - omnivorous animals/fish.

In addition to the above, various decomposers (bacteria, viruses, etc.), which decompose various resolvable organic items (e.g. carcasses of fauna and flora) into nutrition play a highly important role in the energy flow, especially in the sea. This must have been critical when a substantial change in the biological productivity of the sea was taking place. However, both the qualitative and quantitative features of these decomposers have been excluded from this study. Future studies dealing with the topic are awaited.

1/ It was assumed until recently that the causes of the damage to marine life were simple consisting mostly of suffocation by de-oxidization of sea water and partly the toxic influence of a few specific planktons. However, recent research has revealed that the mechanisms responsible for damaging living resources are highly complicated, variable and include a kind of neurotic paralysis, e.g. loss of respiratory function caused by some toxic secretion (Hanaoka et al., 1980).

Some species bypass an intermediate stage of the flow, e.g. gizzard shad is a herbivorous fish so the energy flow is from "phytoplankton" to "fish" missing out "zooplankton" in this case. The fish is harvested by the shad fishery. In general, the fisheries harvest the animals or fish, as a commercial product, at various stages/levels of the energy flow in each system. For instance, the catch of anchovy and "shirasu" are products of the third level as planktivorous fish and amberjack (yellowtail) is at the fourth stage as a as piscivorous fish in the first subsystem. Similarly, abalone and sea urchins are at the second level, shrimps and soles are at the third, and sea breams and octopuses are at the fourth level in the second subsystem. However, these subsystems are distinguished by the fact that the highest level is represented by piscivorous fish in the first and omnivorous animals and fish in the second.

Generally speaking, it is not easy to examine these two subsystems through data observed in the field. Tatara(1981) applied detailed statistics1/ to these sub-ecosystems to examine changes in ecosystem of fishery resources in the Seto Inland Sea. He allocated the catch by species and species-group into the assumed food-web group in each of the sub-ecosystems. Table 6 shows the results of the allocation employed (Tatara, 1981, modified by the authors).

Before going into the details of the results obtained , it should be noted here that the application of fishery statistics to such ecological concepts inevitably involves substantial bias and distortion caused by various factors. These factors include (a) the selective function of some types of gear employed, (b) species preference practiced by fishermen, (c) the change in food items (feeding habit) of fish according to growth stage 2/, (d) the intermingling of fish to and from the region, etc. The simplification and/or approximation of "food habit" of a specific fish or species-group in allocating the catch data into the appropriate food web category (Table 6) also generates substantial bias.3/

However, it is worth examining the ecological concepts of the catch and exploitable resources, as far as possible, to clarify the biological features involved in a systematic way. Such an examination could be carried out by analysing the data on a comparative basis, applying the same standards and rules within a defined framework.

The compilation of species caught, allocated into each trophic level by food item in each subsystem (from 1 to 4 for each, see Table 6), can be roughly regarded as representing the standing-state of the exploitable

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1/ The statistics employed were those at the prefectural level compiled by the branch offices of the Statistics and Information Department, Ministry of Agriculture, Forestry and Fisheries, deployed in each of the prefectures bordering the sea. These statistics are more detailed in terms of the species and area break down than the nominal national statistics.

2/ For instance, almost all fish are planktivorous during their larval and fry stages, even those that acquire a piscivorous or omnivorous food habit in their adult stage.

3/ Chub mackerel and Jack mackerel are basically planktivorous, but they have acquired an omnivorous nature too, feeding intensively on various suitable items whenever they are encountered. This is why these fish have been commercially caught by pole-and-line or handline. However, they had to be placed in the planktivorous category due to a lack of information with which to make suitable adjustments.

Table 6. Allocation of species and species-groups to sub-ecosystem and trophic level by major food items. Figures are given in percentages (each species/species-group = 100%) (Tatara,1981, modified by the authors).

Food Item:

(PST): Photosynthesis PHP: Phyto-plankton ZOP: Zoo-plankton
FIS: Fish ANM: Various animals DET: Detritus

(%)

Species/ species-group 1/	Food-web system 2/							
	Planktivorous-Piscivorous system				Benthos feeding-Omnivorous system			
	Trophic level and food item				Trophic level and food item			
	1 (PST)	2 PHP	3 ZOP	4 f FIS	1 (PST)	2 PHP DET	3 ZOP ANM	4 ANM FIS
"Wakame" seaweed	50				50			
Other seaweeds	50				50			
Gizzard shad		100						
Sardine		50	50					
Anchovy			100					
"Shirasu"			100					
Chub mackerel			100					
Jack mackerel			100					
Butter fish			100					
Sandlance			100					
Amberjack				100				
Spanish mackerel				100				
Bastard halibut				100				
Lizardfish				100				
Sea bass				100				
Other fish			15	35			15	35
Largehead hairtail				50				50
Sea urchins						100		
Sea cucumbers						100		

Continued

Table 6 Continued

Abalone		100		
Top shell		100		
Hard clam		100		
Baby clam		100		
"Mogai" clam		100		
Pen shell		100		
Other shellfish		100		
Polychaeta		100		
Other benthos		50	50	
Other shrimps			100	
Other crabs			100	
Kuruma prawn				100
Mantis shrimp				100
Blue swimming crab				100
F. spotted flounder			100	
Other flatfish			50	50
Mullets			50	50
Croakers				100
D.g. pike-conger				100
Red sea bream				100
Black sea bream				100
Common conger				100
Rockfish				100
Sharks				100
Skates				100
Cuttlefish				100
Squids				100
Octopuses				100

1/ The species and species-groups referred to here are those defined and listed in the detailed nominal statistics available for the catch by sub-area of the Seto Inland Sea (see text for the details).

2/ See text for the details of the sub-ecosystems.

resources in the sea.1/ However, it should be kept in mind that the total marine catch represents only a part of the biomass pyramid of the entire ecosystem. The mean value of the numbers of trophic level (as defined above) for the total catch, calculated by weighing the catch for each level, is an indicator of the "standing state" of the exploitable resources as a whole in terms of the centre of gravity of the biomass pyramid of the entire catch or exploitable stocks.2/

(1) Change in total production by sub-ecosystem

The annual change in the total catch from 1951 to 1977 by subsystem and subregion of the sea (east and west) is shown in Figure 7. All catches show a steady increase over the years, which accords with the change in the total production of the sea (see Subsection 6.3.1 and Figure 6). This indicates that the increase in the biological productivity of the sea applied to all resources and areas.

However, it is important and interesting to look at some differences in trend among the elements examined. First, the dominance of the two subsystems is reversed between the two subregions, that is, the piscivorous system is dominant in the east while the omnivorous system dominates in the west.

Second, the rate of increase in catch differs greatly by subregion and subsystem. It was the highest in the piscivorous catch in the east, which more than doubled during the period, while that in the west was rather stagnant although the total increase had nearly doubled. By contrast, the omnivorous catch in the east was rather stagnant over the years, while that in the west increased steadily, the catch more than doubling. These facts indicate that large and various differences in the processes increasing biological production in the ecosystem occurred depending on the structure of the system and, it is assumed, on the environmental conditions in each subregion.

(2) Change in "standing state" within sub-ecosystem

Figure 8 shows the relationship between the annual index of standing state 3/ and the annual total catch by sub-ecosystem and subregion. All the relationships show a negative correlation. The curve moves generally from upper left to lower right as total catch increases. This means that the centre of gravity of the catch moved to lower trophic level during the period under review. It is interesting to note a consistent flat-bottom tendency over the subsystems and subregions.

1/ The "state of organisms in a biomass pyramid at any one moment" examined (Odum, 1971, Lapedes et al., 1978).

2/ The mean value indicates the relative position of the catch in the trophic levels defined above. However, it may not be strictly correct to call it an "average trophic level".

3/ The centre of gravity of the biomass pyramid of the catch in terms of trophic level. See the earlier part of this subsection and Table 6.

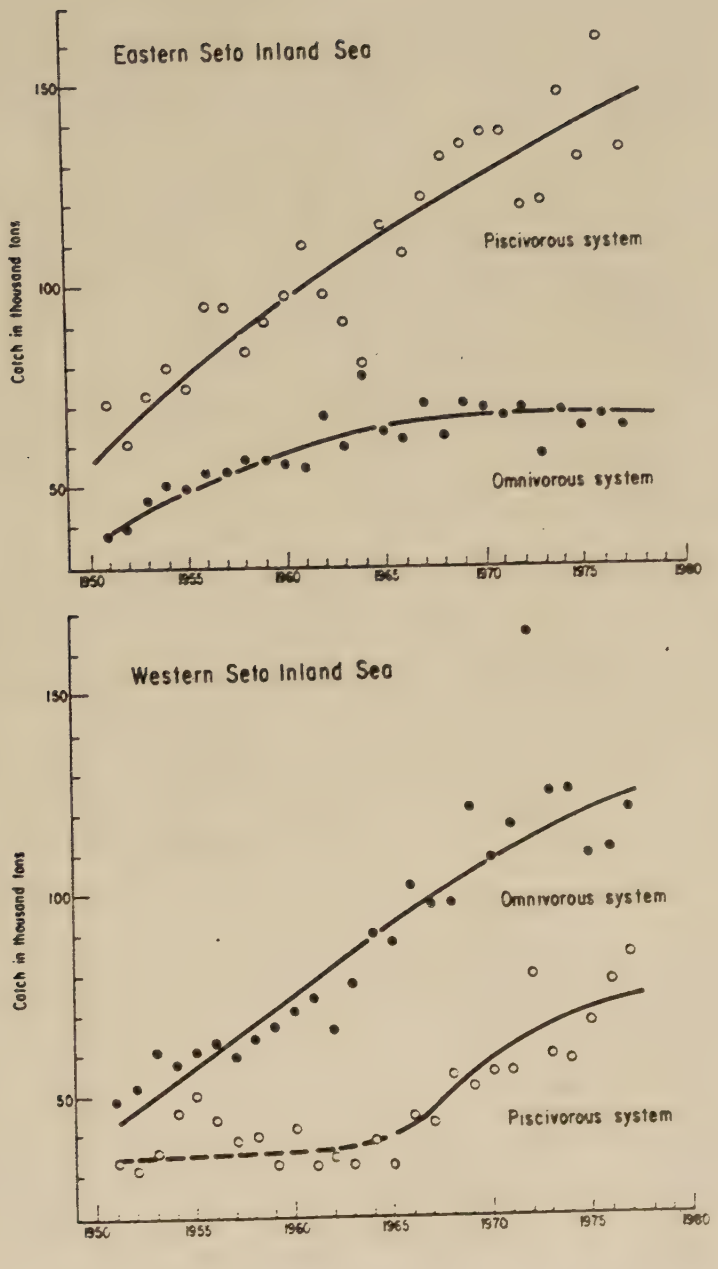

Figure 7. Annual change in the total catch by sub-ecosystem and sub-region of the Seto Inland Sea (Tatara, 1981a, modified by the authors). See text for the details of the definition and remarks of the sub-ecosystems.

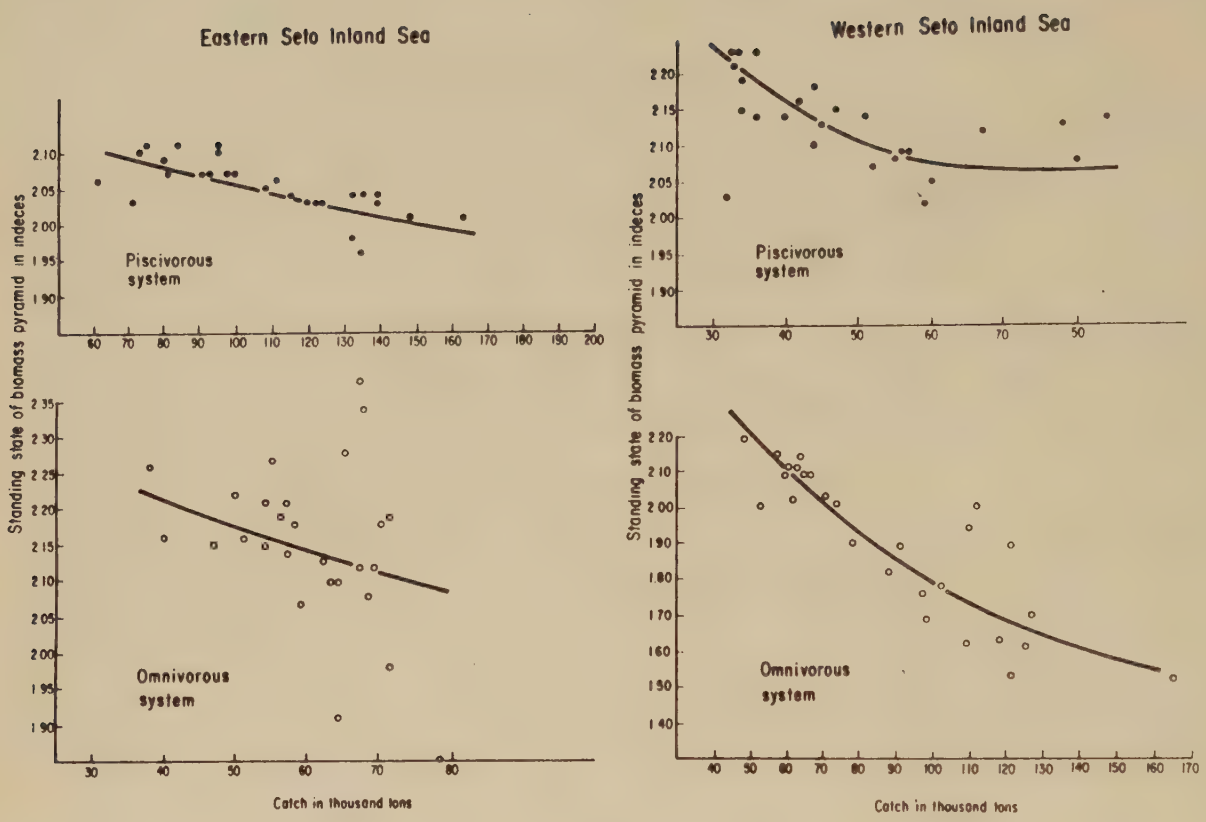

Figure 8. Relationship between the annual total catch and the index of the "standing state" of the biomass pyramid of the catch by sub-ecosystem and sub-region of the Seto Inland Sea (Tatara, 1981a, modified by the authors). The index shows the "centre of gravity" of the biomass pyramid of the catch, which shows also a relative position of trophic level, see text and Table 6 for the details.

In the omnivorous system, the decline in the level was most marked in the western sea, while that in the east was the weakest overall and subject to large fluctuations. It can be seen in the piscivorous system that the curve has flattened out at a considerably higher level in the west than in the east. These facts suggest that more resources in the omnivorous system had become available in the west, while more of those in the piscivorous system became available in the east over the period. It is also noticeable that the resources at higher trophic levels were to be found more in the west than the east.

In conclusion, a change in the sea's ecosystem certainly did take place, in conjunction with the eutrophication of sea waters, from 1951 to 1977. But the changes in the structure of the ecosystem (biomass of each species and species-group, and supposedly, inter-species relationships, etc.) are markedly different between the east and west of the sea. These changes have resulted in differences in fisheries production between the two subregions as the final outcome of the enhancement in biological productivity. In other words, the fisheries in the Seto Inland Sea are dependent upon two different ecosystems, i.e. the piscivorous system in the east and the omnivorous system in the west.

6.3.3 Change in catches of major carnivorous fish of commercial value

Major changes can also be observed in a few specific fish stocks in the sea. Figures 9 and 10 show long-term changes in the annual total catch of a few selected carnivorous species taken from the entire sea over the past 34 years, 1951-85. All the fish are at higher trophic levels, feeding intensively on fish and other animals at their adult stage, and are of high commercial value. They include red sea bream, bastard halibut, daggertooth pike-conger, Japanese sea bass, Japanese Spanish mackerel, lizardfish (Figure 9), and largehead hairtail (see Figure 10). The stock levels of all these show fluctuations over the years produced either by man-made or natural causes. These are summarized as follows:

(1) Stocks once depleted by overfishing but recovering

The first three species, red sea bream, bastard halibut and daggertooth pike-conger, are traditionally very important to the fisheries in the sea because of their high commercial value. The abundance of these species once declined substantially with the overall development of the fisheries in the sea, which resulted in a sharp and continuous decline in the total catch of these fish during the 1950's and 60's (Figure 9). The size of the fish caught also decreased during the same period. The loss in net economic return to fishermen harvesting these fish was serious caused by a decline in the catch rate coupled with a lower market price for fish of smaller size. These were apparently typical symptoms of overfishing, as far as these three species were concerned. It can be seen, however, that this overfishing occurred while the substantial increase in the total biomass of exploitable fish was taking place in the sea (see Subsection 6.3.2 and Figures 6 and 7).

These symptoms were soon recognized as serious by all the fisheries research institutes and administrations in the region, not long after the strong complaints were made by fishermen. However, there was no simple way to resolve the problem, because of the complexity of the fisheries and of the resources fished.

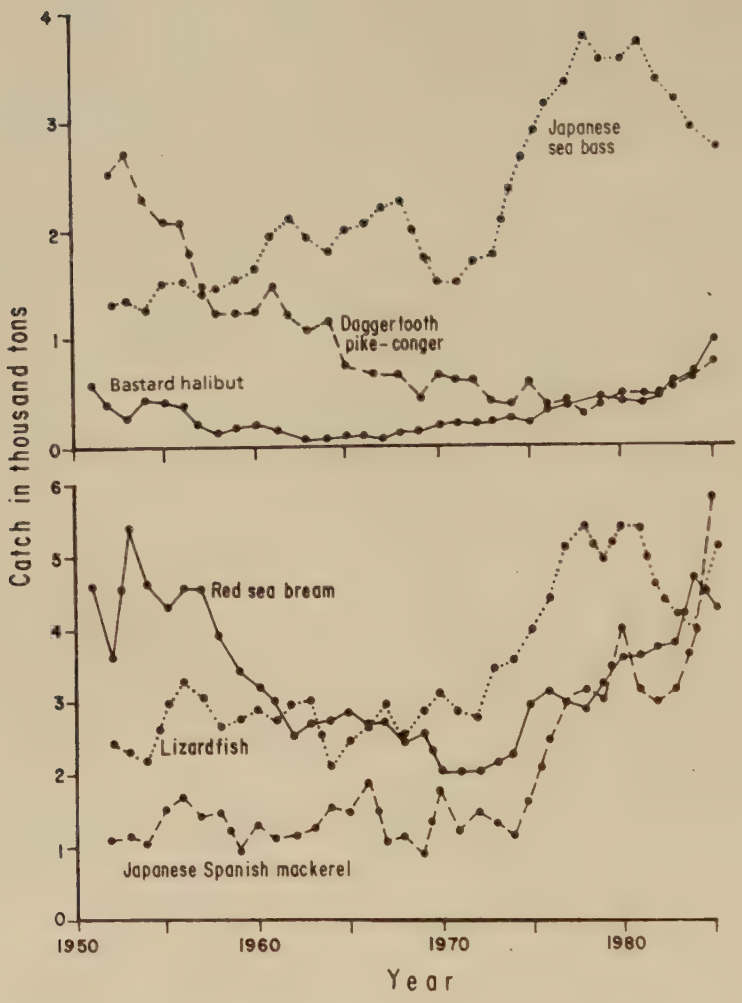

Figure 9. Long-term changes in annual catch of major carnivorous fish species of high commercial value caught in the Seto Inland Sea, 1951-85 (see Appendix Table 1 for statistics).

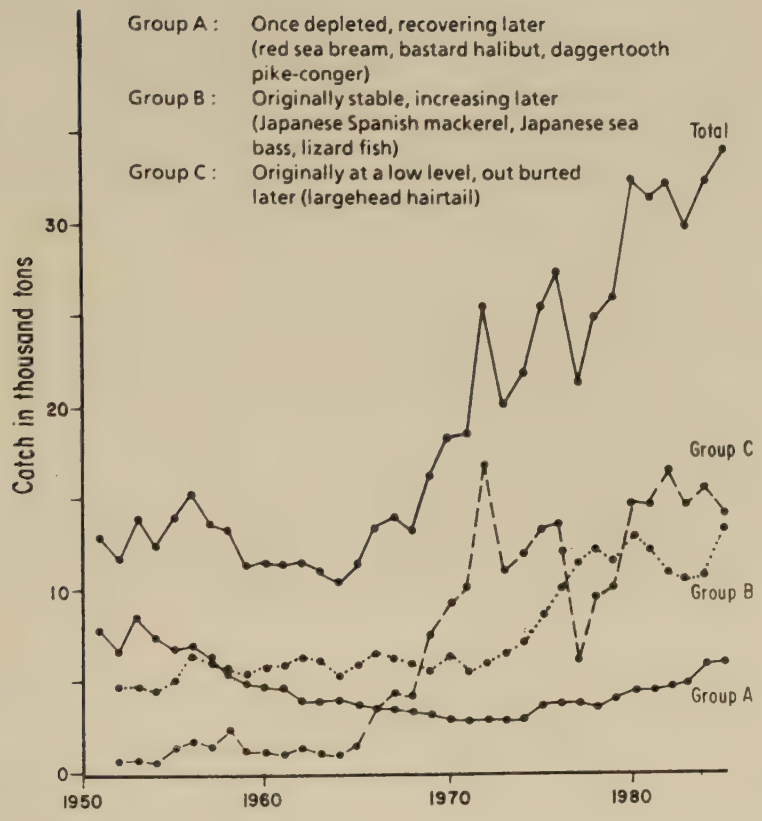

Figure 10. Long-term changes in annual catch of major carnivorous fish species of high commercial value by fish group caught in the Seto Inland Sea, 1951-85 (see Appendix Table 1 for statistics).

In these circumstances, the local governments decided to modify the system of regulatory measures, and introduced strict and more comprehensive measures than those employed before. The adjustment had two principle aims. The first was the protection of spawning stocks throughout their life and in particular spawning grounds and seasons, and the second was stronger protection of the nursery grounds of these fish, which were commonly distributed in the seaweed-bed area (or "underwater sea grass forest"). Various additional limitations on fishing operations by efficient gear (e.g. mechanized surrounding seines for red sea bream or mechanized small-scale trawls for bastard halibut), closure of specific grounds to almost all fisheries during the spawning and breeding seasons, etc. have been imposed since then.

In the meantime, the annual total catch of the first two species began to increase (Figure 9). It started first in the catch of bastard halibut around 1965, about ten years after the initial decline, and second in red sea bream around 1970, about fifteen years after initial decline. These increases continued over the following years. Recent catches of bastard halibut far exceed those taken during the early development of the fisheries, and catches of red sea bream have almost recovered to their previous levels. The catch of daggertooth pike-conger still remains at a low level, but firm signs of recovery have been seen since around 1980, about 25 years after the initial decline (Figure 9). There is no doubt that the these stocks have been consistently recovering in recent years.1/

The recovery of these fish stocks would have been a result of various factors. The authors are inclined to hypothesize that the comprehensive and strict management measures employed in the fisheries in the sea, specifically those dating from the mid 1960's, played the most important role in the recovery. The increase in the prey biomass, mentioned previously, would certainly have aided the recovery too. However, the main trigger for the recovery must have been the employment of proper management, and not environmental factors. This must be examined in more detail by future studies. However, our hypothesis enables us to make a projection. Namely, a serious decline in stocks of these fish would not occur in the future only by man-made causes, if the enforcement of present management scheme is effectively maintained.

(2) Stocks previously stable but increasing later

The other four fish species are Japanese Spanish mackerel, Japanese sea bass, lizardfish and largehead hairtail. Annual catches of the first three species had been fairly stable until around 1970 (Figure 9) and for the last, until around 1965 (Figure 10). These were maintained despite the rapid development of the fisheries in the sea, which resulted in an overall increase in the total catch throughout the years. However, the catches of all four species have markedly increased, the first three since about 1970 (Figure 9), and the last since about 1965 (Figure 10). These phenomena indicate that a large increase in stock abundance had undoubtedly taken place for each of these species, too.

1/ The difference in the time-lag between decline and recovery may be chiefly a result of different biological features of these fish, especially as regards in life cycle. For instance, basterd halibut reach first maturity at age 2-3 years (youngest), while red sea bream do so aged 3-4 and daggertooth pike-conger at 6-7 years of age. The difference in reproductive potential (e.g. spawning magnitude and natural mortality rate during early life stage, etc.) would also have been an important factor.

The species-specific biological features of these fish might have functioned to keep stock levels stable during the initial period. These may include the limited catchability of the fish by specific kinds of gear, e.g. gillnets, hook-and-lines, trolls and setnets are all passive in nature (see Subsection 5.2), and the movement of stocks to and from outer seas, etc. These would have prevented the fish being exposed to rapidly increasing fishing intensity by more efficient types of gear like mechanized purse seine, boat seine and trawl in the early stage of fisheries development in the sea. But this explanation should be examined in detail by future studies.

More important, it should be noted that a sudden and rapid increase in these stocks began during the period of 1965-75, consistently to all the species mentioned above (see Figures 9 and 10). Catches in recent years are double to triple what they were during the stable period for the first three species (reaching about 4-5 000 tons for each), and about 15 times what they were for largehead hairtail (reaching about 15 000 tons). These catches are assumed, with little doubt, to represent the current levels of these stocks. It is probable that the growing abundance of prey animals would have supported the increased biomass of these species. However, abundant prey cannot be the only factor responsible for the increase; another factor, or various others, must have been involved.

It should be noted that a similar phenomenon has been observed in the catch of filefish, Navodon modestus (Gunther). An extra ordinary increase in the catch has been reported from southern and western Japan since around 1965 (Kobata, 1981, Kanagawa Prefecture, 1981). Evidence of the growing numbers of the fish has been clearest along the central Pacific coast of Japan, where huge catches by setnets along the coast are frequent (Kobata, 1981). Unfortunately, the state of filefish in the Seto Inland Sea is not yet known as separate catch statistics are not available at present. However, the situation probably resembles that described above.1/

It is interesting and amazing too, to look at the similar phenomena reported widely from the southwestern part of the Northwest Pacific Ocean. Remarkable increases in the catches of largehead hairtail and filefish have been reported from the waters along the west coast of the Korean Peninsula and northern China bordering the East China Sea (Chikuni, 1985). The timing of these increases concurs with that in the Japanese waters, during the period 1965-75.

At present, the main causes of these phenomena, in both the East China Sea and Japanese waters, are not clear, and future studies to be carried out by the institutes concerned are awaited. However, an important point to bear in mind (especially in connection with the subject of this paper) is that both largehead hairtail and filefish are eurybath in nature and omnivorous with greedy feeding habits 2/, factors that must be critical in the inter-species relationships in the entire ecosystem of a fish community. This implies that observations over a wide area beyond the framework of the Seto Inland Sea are required, first to clarify the technical aspects involved, and second to establish adequate management measures, if needed, which may require a global scheme covering areas well beyond the Seto Inland Sea in some cases.

1/ It has been reported that the fish started to increase in the Seto Inland Sea around 1968-69 (Kakuda, 1976, 1980).

2/ These features may be clues that point toward an explanation of these changes.

In any case, an astonishingly large change in stock level of carnivorous fish species of commercial value has occurred in addition to large changes in the abundance of resources and the entire ecosystem in the Seto Inland Sea. The combined total catch of species whose stocks have recovered in recent years is more than 1.5 times the catch during the early development of the fisheries, and that of fish whose stocks have just recently begun to increase is nearly 3 times as high as it was in that period (Figure 10). Studies and appraisal are eagerly awaited to clarify these phenomena, as this is the first time that this phenomenon has been experienced in the history of the fisheries and resources in the sea. Apart from the natural causes involved, the authors believe that the success in fisheries management in the region has played an important role in these changes.

6.4 Production by Aquaculture

Apart from the capture fisheries discussed so far, the aquaculture fisheries have a highly important role to play in the comprehensive use of the sea. All the aquaculture fisheries are legally part of the "Demarcated fishing-right fishery", which is one of the "exclusive-use right" fisheries of the coastal zone, together with the setnet fishery (see Section 2 and Tables 1 and 2). The majority of the rights have been granted to fisheries co-operatives especially those for culturing seaweeds and oyster, while those for fish and prawns are granted chiefly to individual fishermen or entrepreneurs. The aquaculture granted to a fisheries cooperative forms a very important element in coordinating all fisheries under the self-regulatory scheme of the co-operatives, particularly in coordinating the "successional fisheries", as discussed in Section 3.

Aquaculture in the sea has a long history, especially that for oyster and laver ("Asakusa-nori", red seaweed). Similarly to capture fisheries, aquaculture in the sea has developed remarkably after the Second World War. The development of the fisheries had nearly reached its maximum level around the mid 1960's in terms of the amount of space utilized, and annual total production reached about 150-200 000 tons. The production of these fisheries, however, continued to grow, benefiting from the improvement in aquaculture technology, and has reached a level of more than 300 000 tons level in recent years.

Besides the development of the traditional oyster and laver culture, fish and shrimp culture were initiated on an industrial basis in the sea in the early 1950's. Fish culture, (including shrimp culture 1/ other than specified), has developed rapidly in recent years, being boosted first by the remarkable development in rearing and artificial seeding technologies, and second by the plentiful and stable supply of fresh feed material since around 1970 (provided by massive catch of chub mackerel, sandlance and more recently sardine from the coastal waters around Japan). It has also been stimulated by the strong demand for its products, brought about by a change in consumer preferences toward luxurious sea food in recent years. The total annual production of fish culture has reached about 15-20 000 tons recently, which includes various species such as amberjack, red sea bream, Jack mackerel, bastard halibut, black sea bream, puffer, filefish, kuruma prawn and octopus.

The aquaculture in the sea can be grouped into two different categories: one without and the other with feeding. Seaweed (laver and "wakame" or Undaria pinnatifida) and oyster culture are included in the first group, while fish culture is in the second. Figure 11 shows annual production by type of aquaculture and by major species together with the total amount of feed used for fish culture during the past 15 years.

1/ Almost exclusively the culture for kuruma prawn.

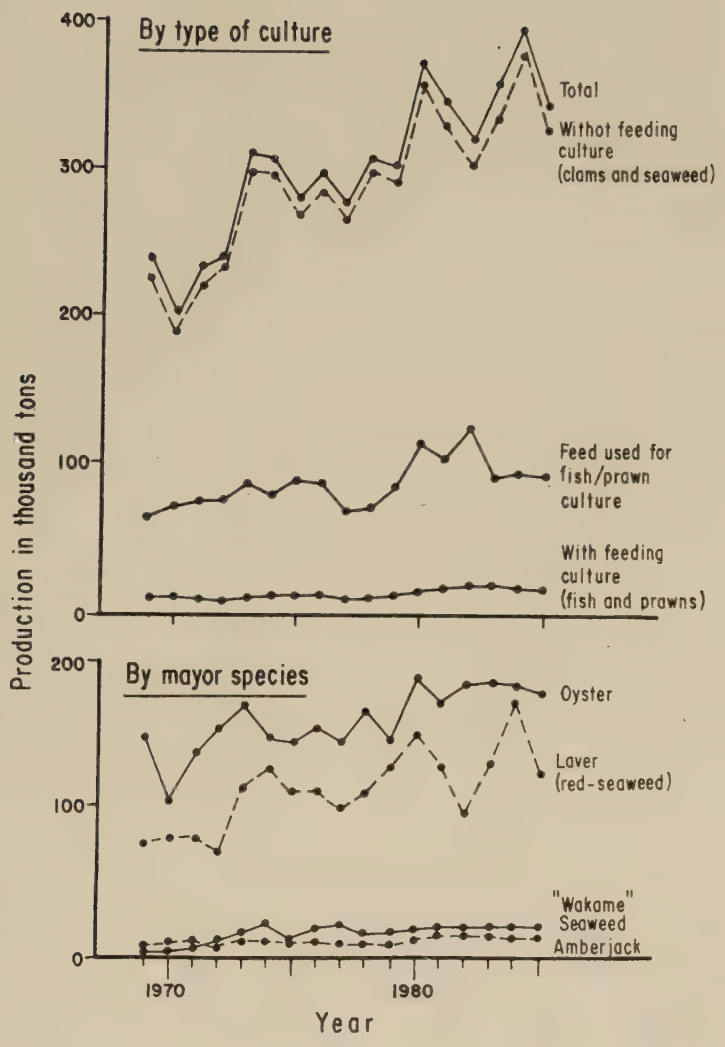

Figure 11. Annual change in aquaculture production by type of culture and major species in the Seto Inland Sea, 1969-85. The amount of feed used for fish/prawn culture is also shown (see Appendix Table 2 for statistics).

The nutrition required for seaweed and oyster is entirely natural. These is therefore no doubt that favourable environmental conditions over the years have greatly facilitated larger production of these aquaculture as well as other fisheries. In particular, the increased production of living resources in the sea in conjunction with the eutrophication of sea waters has played an important role in this group too. The current level of production (about 100-150 000 tons of seaweeds, 170-180 000 tons of oyster, totaling 300-350 000 tons) is as great as the capture fisheries' production at lower trophic levels (total production being 420-480 000 tons). The data are insufficient at present to look in further detail at the relationship between the eutrophication and the products. This needs future studies.

In contrast, fish culture production is very small in terms of quantity at about 15-20 000 tons in recent years, although it is great in value. Apart from its profitability, a notable fact relevant to the subject of this paper is that the feed used for fish culture is about 5-6 times the level of annual production, at 90-100 000 tons, of which about 95 percent is fresh or frozen fish, clams, shrimps, and/or krill. These must have accelerated the eutrophication of the sea, and occasionally caused pollution or the red tide mentioned previously. This implies that monitoring under comprehensive and careful management is required, covering all the fisheries in the sea.

6.5 An Overall View

The annual total catch from the entire sea has markedly increased during the period under review: 120-150 000 tons in the 1930's and 40's, 200-250 000 tons (1950's), 250-380 000 tons (1960's), 380-420 000 tons (1970's) and now approaching 500 000 tons in the mid-1980's. By the mid 1960's there was no room left for further development since the fisheries covered almost all the available fishing grounds in the sea and the annual catch was about 300 000 tons. In fact, the total number of fishing vessels in the area has not substantially increased since then. It is therefore clear that the remarkable increase in the total catch thereafter is attributable mostly to the increase in exploitable biomass caused by the greater productivity of the sea rather than the development of fisheries or the improvement in fishing technologies.1/

However, this increasing productivity affected the exploitable fishery resources in different ways according which sub-ecosystem they belonged to. For instance, it favoured the production of a larger biomass of planktivorous pelagic fish in the east, and of the benthos/detritus-feeding animals in the west. As a result, the "centre of gravity" of the entire biomass of resources, and eventually the catch, has moved to a lower trophic level than before. In other words, the fisheries in the sea have been flexible and changed their target species (not a single species but a combination of species) in accordance with change in the exploitable resources.

This tendency can be observed not only in the fisheries as a whole, but also in the species-specific fisheries, which have also become more flexible according to changes in their target stocks. This type of flexibility is very important, particularly when the stock has been depleted by overfishing and strict regulatory measures are required for those stocks. If the fisheries can survive by flexible fishing in some way and the regulatory measures are enforced effectively, depleted stocks have a chance to recover. The fisheries can then resume fishing their original and profitable target stocks, once those stocks have recovered. The red sea bream and bastard halibut fisheries in the sea are two good examples of such a cycle (see Subsection 6.3.3, item (1)).

1/ The situation is quite different for aquaculture, where various improvements in technology have made greater production possible (see Section 6.4).

Such flexibility, not arbitrary but strictly managed functions for the fishermen concerned as compensation in some cases, and as further development or expansion of their fishing in others. The recent catch of carnivorous fish species of high commercial value may be an example of this (see Subsection 6.3.3 item (2)).

In conclusion, a fishing strategy based on a combination of (i) the flexible but well designed fishing by fishermen and (ii) the comprehensive and detailed management and coordination by fisheries administrations and by fishermen themselves is indispensable to achieve the best possible utilization of resources in a limited sea area. Management should cover both the capture fisheries and all the aquaculture of the region. Such a strategy would surely enable the fisheries and fishermen to survive in some way, even when substantial changes temporarily occur in target fish stocks for some natural or artificial reason (e.g. overfishing or pollution). This strategy would also ensure the harmonious and effective utilization of the limited sea area and resources, producing the largest possible benefit for all.

The "largest benefit" mentioned here does not refer only to maximum profits for a specific fishery or fisheries, but to the socio-economic benefits for all fishing communities in the region and the overall benefit to the national economy and welfare. The fishing strategy should therefore be decided first by the fishermen themselves according to the state of marine resources and the socio-economic conditions in each fishing community in the region, and then be controlled and coordinated by the fisheries administrations according to the priorities of local and national policy.

The authors believe that the fisheries management employed in the Seto Inland Sea, based on lessons learnt from past failures and success, is a good example of comprehensive utilization of fishery resources in a limited sea area.

7. DISCUSSION

7.1 Resources and Environment

As discussed in each of the previous sections, the multispecies resources inhabiting the coastal waters around Japan are largely native species.1/ A large number of species are involved and their biological features differ greatly. These features determine (i) the species composition of the various fish communities harvested in specific waters, (ii) the amount of catch to be taken for each species and as a whole, and (iii) the fishing methods and types of gear employed. Needless to say, variations in this framework of exploitable resources are determined also by environmental conditions in each of the specific waters in the region. Therefore, when the management strategy for a multispecies resource in a specific water is planned, the environmental conditions of the water need to be taken fully into account.

The coastal waters around Japan are characterized by their highly favourable environmental conditions for biological and fisheries production, benefiting from their geographical location (boreal to subtropical) and several prominent sea currents (the Kuroshio, Tsushima Warm Current, Oyashio and Liman Current, etc.). For instance, a variety of stocks are available to the fisheries, including boreal stocks in the north, temperate stocks in the

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1/ Kuruma prawn and skipjack tuna are two exceptions, being cosmopolitan species widely distributed over the world's oceans. The former species is sedentary and no intermingling with others takes place, while the latter is highly migratory and does not always form part of the resources of the region (see Section 5).

central zone and subtropical stocks in the south. The potential harvest of some stocks is huge (e.g. Alaska pollack, Japanese sardine, Japanese chub mackerel, etc.), and various fish of high commercial value are also available although the potential catch is small for each (e.g. bastard halibut, red sea bream, Japanese Spanish mackerel, kuruma prawn, abalone and sea urchins).

The combination of the available species and their catchability varies greatly according to local conditions of the fishing ground (latitudinal location, topographic and oceanographic conditions) annual and seasonal fluctuations in the environment. In some cases, the improvement or worsening of environmental conditions can result from activities entirely irrelevant to fishing, as in the Seto Inland Sea (see Section 6). In short, the history of Japanese fisheries is that of the infinite adaptability of fishermen to various local conditions and their changes from one place/time to another, as discussed in each of the section of this paper (see particularly Section 1).

Another peculiar feature of multispecies problems in Japanese waters is the close relationship between so-called pelagic and demersal fish species. They are sometimes difficult to separate by habitat. These problem originate mostly from the eurybath nature of a few species (e.g. Japanese anchovy, largehead hairtail, Japanese sea bass and filefish) and partly from the complicated inter-species relationships among them (prey predator relationships). For assessment and management purposes, therefore, the so-called pelagic and demersal fish species need to be dealt with together. The Seto Inland Sea complex provides a typical example of this (see Section 6).

Furthermore, the neritic pelagic fish stocks around Japan show a strong multispecies nature within their habitat. Japanese sardine, Japanese chub mackerel, Japanese Jack mackerel and Japanese anchovy have historically formed a complicated fish community in which inter-species relationships might have played an important role in the dynamic change in their abundance. The management of the fisheries for the first three species has, therefore, generally been dealt with as a package for all three. The fisheries for Pacific saury and Japanese flying squid have been treated separately for management purposes because of the highly specific fishing gear employed. However, biological similarities between these species and the above mentioned pelagic fish community means there is competition between them for space and food (as well as prey-predator relationships). Therefore, they also need to be dealt with together in some cases, especially for assessment purposes (see Section 5).

7.2 Fisheries

The multispecies fisheries around Japan are multi-gear fisheries. They can, however, be roughly grouped into two categories according to their size and which fishing grounds they are permitted to use: (1) large to medium-type fisheries in offshore waters and (2) small-scale fisheries in nearshore waters (see Section 2 and Table 2).

The structure of the first group is rather simple, being composed of a few types of highly efficient gear. These include offshore trawls (larger than 15 gross tons), larger one- and two-boat purse seines (over 40 gross tons), medium-type purse seines (5-40 gross tons), saury stick-held dipnet and squid-jigging fisheries. They are not allowed to co-operate in nearshore waters. The second group is a complex of smallscale fishing gear forming a highly complicated multi-gear fishery in each of the nearshore waters where fishing is permitted. The fishing vessels employed in the second are mostly less than 5 gross tons except the small-scale mechanized trawls in defined sea areas and the boat seines in the Seto Inland Sea (5-15 gross tons for each fishery).

We can say, therefore, that these fisheries have a two-layered structure. However, if the situation is looked at in detail, especially that in nearshore waters, the structure can be further divided and becomes multi-layered, with fisheries being defined and characterized by various fishing rights and licences. This includes not only capture fisheries but also aquaculture (see Sections 2, 3, Tables 1 and 2).

The structure of the fisheries and the deployment of their fishing operations in each of the defined sea areas are, of course, the results of the management decision currently taken by central and local governments. However, they are, at the same time, the results of fishermen adapting to the natural conditions in each area throughout the long history of the development of the fisheries. In other words, they currently reflect the tradition and customs kept to throughout the history of each fishing community on the coast. These customs have been shared not only by fishermen but also by almost all social and economic sectors of the fishing communities. They are particularly strong in nearshore waters, a typical example being provided by the "Notsuke" fisheries co-operative (see Subsection 3.2).

As is well known, Japan is one of the traditional fishing nations in the world, where fishing has been one of the most important industries, providing not only subsistence for fishermen and a supply of animal protein for the nation but also a global improvement in the social and economic status of fishing communities and the entire nation (Nagasaki, 1983, Chikuni, 1985, Yamanaka et al., 1988). In this regard, tradition and customs have functioned fairly positively in maintaining social tranquility in each fishing community, and have been extremely effective in resolving conflicts among fishermen (Ruddle, 1987).

This deep-rooted philosophy is shared not only by the people in fishing communities but also by the nation as a whole. This is one of the reasons why, in establishing modern, democratic legal arrangements (laws and acts), those traditions and customs have had to be taken into account (see Section 2). This is also one of the main reasons for the success in organizing various fisheries co-operatives as autonomous co-ordinating bodies at a grass roots level (Nagasaki, 1983, Yamanaka et al., 1988).

7.3 Management

The main components of the management scheme in Japan1/ completely cover the management of multispecies resources and multi-gear fisheries as well as the other fisheries in Japan (see Section 2, Tables 1 and 2). There are four distinctions to be made between this system and those in other countries. They are (1) measures are highly complicated, detailed and comprehensive, (2) flexibility in engaging in different fishing operations is allowed within a defined fishery in a defined sea area, (3) a combination of the limitation of total fishing intensity and various conservation measures is the standard and universal regulatory system, and (4) the active participation of fishermen in the management of resources and fisheries is mandatory and the self-regulatory scheme has been widely established by fisheries co-operatives.

1/ These are (1) the establishment of the exclusive-use right in nearshore zones, (2) the control of total fishing intensity of particular fisheries in defined waters during the prescribed season, (3) the establishment and enforcement of various conservation measures and (4) promotion of co-ordination and co-operation among fishermen.

7.3.1 Complexity, comprehensiveness and attention to detail

These arrangements have been made aiming to cope with target resources that vary greatly over space (regionally and locally) and over time (annually and seasonally) and complex of fisheries with double- and multi-layered structures.

So far as the coastal resources are concerned, almost no measure has been employed in Japan aimed at managing only a single stock. A regulation or directives has usually been designed to cross-refer to other measures or directives. The entire system can thus cover all resources and fisheries with measures whose functions overlap. This is another reason why a catch-quota system is impractical in Japan.

The discussions in Sections 4 and 5 refer to the double-layered structure of large- and medium-type fisheries (trawls and purse seines) in offshore waters and those in Sections 3 and 6 to the multi-layered features of small-scale fisheries (multi-gear capture fisheries and aquaculture) in nearshore zones.

7.3.2 Allowance of flexible fishing

Permission to engage in different kinds of fishing is granted only when detailed and comprehensive measures are strictly enforced covering all resources, fisheries and fishing/farming grounds (including aquaculture). In the Japanese system, such permission and the strict measures are not contradictory but complimentary to one another.

For instance, the economic loss to fishermen caused by various seasonal closures (grounds or fishing) for conservation purposes can be offset by allowing the fishermen to engage in other fishing. However, arbitrary shifts in fishing by fishermen beyond the regime established by the authorities or fishing communities are strictly prohibited. In other words, the management measures in a specific sea area have to be based on comprehensive knowledge of both the resources to be utilized and the fishing communities that will exploit in the area. The latter includes the structure of fisheries and types of gear, profitability of each fishery and type of gear, tradition and customs in the area.

In Section 3 the successful employment of "successional fishing" governed by fishermen themselves is discussed, and in Section 6 a comprehensive management scheme employed in a limited sea area is examined. In both cases it is clear how important the acquisition of such information is for management. The latter case includes examples of both failure (overfishing, pollution and contamination) and success (recovery of depleted stocks and rehabilitation of the environment).

The allowance of flexible fishing has also worked out well for coastal pelagic fish fisheries when a drastic change in the abundance of a specific fish stock has taken place for natural reasons (see Section 5).

7.3.3 Limitation of total fishing intensity

This is quite unique, and a controversial issue when discussed on a worldwide basis. As already noted, the catch-quota system has rarely been applied in Japan but the control of the total fishing intensity has been applied to all fisheries (see Subsections 2.2 and 3.2).

It should be stressed here again that the Japanese system has been derived from both (1) the complicated structure and biological features of the target multispecies resources and (2) the complex and varied structure of the fisheries, and socio-economic conditions of the fishing communities. The system is, therefore, highly theoretical in terms of its biological and socio-legal concepts, but it tends indirectly to control fishing mortality by making use of analytical methods to calculate population dynamics which have been commonly applied to fisheries in the other advanced fishing countries.

The strong and frequent argument employed against the Japanese system is the "untimeliness" of measures or the "time lag" before they take effect. That is, control of total fishing intensity sometimes tends to be too late to cope with a rapid decline in stock abundance, especially that caused by over-fishing. This is true, first because the formalities necessary for a reduction in fishing intensity (a reduction in the number of vessels or the number of days they can fish) take some time to be completed and agreed upon, and second because a reduction in the expected catch of the target species is a somewhat vague idea since fishing would be continued in some way.

However, it is also true that catch limitation is generally impractical and is sometimes inapplicable to the coastal fisheries around Japan, as seen in Subsection 2.2. There is no doubt about the effectiveness of a catch quota or catch-limitation system as a direct measure if applied when monitoring and surveillance can be properly carried out. Even in Japan, such measures have been taken when these conditions were satisfied, although these have mostly been on a local basis and limited to a few species (see Subsection 3.2).

Apart from the question of practicability, measures to control total fishing intensity involve a few critical disadvantages from a biological point of view. First, expectations of a reduction of a specific catch may not always be fulfilled, owing to fishermen's preferences; second, the process involved in the reduction of a catch is generally a vague one, lacking a clear visual evidence; third, recovery of depleted resources requires a long time enough to allow the process to continue over a few generations. The time required will depend on the life cycle and reproductive potential of the stocks in question.

However, the system has worked quite well for a few depleted stocks of commercial value in a highly complicated multispecies fish community harvested by various multi-gear fisheries. The recovery of three stocks of commercial value in the Seto Inland Sea provide a firm evidence for the above (see Subsection 6.3.3). This recovery has taken a long time (10-20 years). However, the fisheries have survived by changing to other types of fishing, employing the successional fishing that is another distinctive feature of Japanese multispecies fisheries (see previous Subsection and Section 3).

The time required for stocks to recover can be shortened if stronger regulations are employed and strictly enforced, but such action is not always practical in Japan from a socio-economic point of view. This is because multispecies resources in coastal waters around Japan, which support a huge fishing population along the coast, are continuously harvested by various fisheries allowed to perform successional fishing. Fisheries administrations must have up-to-date information all the time on the status of stocks in question, and they must examine carefully all the likely effect of measures, particularly sever ones, that may be adopted; but the decisions on the kind and magnitude of regulations to be employed are not only technical. They are the responsibility of the political sector, and are decided according to the priority areas regarding local and national policies.

7.3.4 Participation of fishermen in management and co-ordination

This subject has already been discussed in all sections of this paper. The authors therefore highlight here only two issues.

First: the fishermen's (including their families) active participation in fishery management and co-ordination has been achieved depending completely upon the socio-economic conditions of the fishing communities and the general philosophy conceived by the entire nation. The tradition and customs upheld by the fishermen have been fully taken into account in political arrangements and they are all understandable and generally acceptable to most of Japanese society.

It can be said that tradition and customs providing harmony, fairness and equity always preceded the legal arrangements or political action taken by governments during the initial stages of fisheries development. Then modernization and democratization were incorporated into the system in accordance with the development of the fisheries (in terms of technologies, economic returns and living standards), acquisition of knowledge on resources (see next paragraph) and overall improvement in industry and national economy. That is, various political arrangements were made to maintain the position of the fisheries sector among other national industries.1/

Second: enough information on the details of (i) the resources and environment (biological, ecological, oceanographic and topographic) and (ii) fisheries (technological, functional, traditional, and socio-economic) in question is indispensable for both the establishment and the enforcement of the self-regulatory measures. In other words, the governments (national and local) have to provide adequate advice on a continuing basis on both the biological and practical aspects of the management to be employed. In Japan, a service able to provide this has been given top priority in the resources research and assessment being carried out by both national and local institutes.2/

7.4 Applicability of Management in General

The authors present here brief general guidelines for the management of multispecies resources and multi-gear fisheries for countries where a suitable management scheme has not yet been established or modification of those currently employed is being planned. These guidelines have been derived from the case study presented in this paper. They cover issues, strategies and tactics mostly experienced or examined in Japan. There may, therefore, be other items or subjects for which reference needs to be made to other papers.

7.4.1 Issues

(1) Resources and environment

Generally speaking, the complexity and instability of multispecies fish resources may be universal to the world's oceans, although the magnitude of the diversity and variability differs greatly from one region to another. The fishermen and fisheries, in any part of the world, who intend to harvest a

1/ Subsidies and incentives, both direct and indirect, which include various programmes on the rehabilitation of fishing and nursery grounds, deployment of artificial reefs, the fisheries forecasting service, fish farming and artificial seeding, etc.

2/ See Yamanaka et al., (1988) for details on the infrastructure and activities of coastal fisheries research institutes at both national and local levels.

multispecies resource, therefore have to adapt to the manifold local conditions. The Japanese case presented in this paper is merely an example of adaptation to natural conditions (in this case, settled in the waters around Japan); but intensive research and studies on the resources and the environment must first of all be carried out to meet requirements for the management of multispecies resources.

(2) Fisheries

In contrast to the biological and environmental features, there may be few universal elements involved in the fisheries, especially those in coastal waters. This is chiefly because of the highly tradition oriented nature of local fisheries. This nature tends to be strongest in countries where fishing has historically contributed to both the local and national economy and welfare (a so-called "fishing nation"). This important fact must be taken into account when a management scheme is established or adjusted in such a country. The factors that must be taken account of in setting up such a scheme naturally differ greatly from one nation to another.

In a country where fishing has been performed without such tradition or social involvement (a so-called "non-fishing nation"), the fisheries are more simply structured being governed mostly by the economic principles (industrial profitability) or by political concepts (e.g. the need to provide a supply of animal protein or employment opportunities). The management issues and strategy are therefore quite simple, and are probably limited to considering how to maximize profits and/or ensure a sustainable yield. However, the management measures to be employed are not simple even in these cases, from a technical point of view, if the fisheries are composed of various types of gear with different selective functions.

In any case, enough information on fisheries is indispensable to decide the kind and magnitude of management measures required. The the coverage and quality of the information is specifically crucial for management purpose in the first case.

(3) Fishermen and organizations

In a "fishing nation" the socio-economic condition of fishermen (including their families), and the fishing community, and the relationship between that community and local society are critically important to establish an adequate strategy and tactics. Organizations or associations of fishermen (and fisherwomen, wives), if soundly established, are extremely useful for all kinds of activities important to the community but not falling under the heading of management of resources and fisheries (e.g. extension, education, training, making arrangements for security, mutual and social welfare, etc.). However, the organizing of such bodies needs to be based on a thorough knowledge of the socio-economic conditions of the fishing communities.

Making provision for harmony, fairness and equity among fishermen and fisheries is the most important consideration. Studies on conflicts and their history could make a most useful examinations to help in sorting out practical approaches.

The kind of organizations to be established will vary according to the conditions (e.g. socio-economic, structural, legal, etc.) in the country and the fishing communities in question. These should be considered case by case.

7.4.2 Strategy

The establishment of an adequate strategy is the responsibility of the fisheries administrations at both national and local levels. The issues discussed in the previous subsection must be taken fully into account in

establishing a strategy. The tactics to be employed, which discussed in the following subsection, are also indispensable elements in establishing the strategy. In short, a global and thorough examination needs to be made.

For instance, overfishing of specific fish stocks may not always be crucial to the fishing community, society or country. On some occasions, a political decision needs to be made on whether to aim for (i) a larger catch of less commercial value, (ii) a smaller catch of high commercial value, or (iii) a combination of these. Furthermore, such a choice needs to be flexible in accordance with changes in resources and fisheries. This is not easy, especially when the guiding principles of harmony, fairness and equity must be borne in mind.

7.4.3 Tactics, infrastructure and incentives

(1) Measures

Management and conservation measures applicable to resources and fisheries vary greatly from one case to another. The applicability of all the conceivable measures should be examined in connection with the issues concerning in the resources and fisheries. Thus a comprehensive list of all appropriate and applicable measures could be made. For instance, if the situation allows, a system based wholly or partially on catch-quotas could be introduced. If not, alternatives like the Japanese system or a combination of these two could be introduced.

There may be no simple or easy-to-apply measure in managing multispecies resources and multi-gear fisheries, with the probable exception of a drastic regulation like "total ban" of a particular fishing gear. The situation is more complicated when the strategy is chosen to combine the "large low-value catch" and the "small high-value catch" mentioned above. In such a case, a comprehensive scheme with various complicated and detailed measures is required, as it is in Japan.

In short, a combination of all measures that can applied to the local conditions in each of the communities in question should be employed. Besides the technical aspects of the measures, their acceptability to fishermen and the costs and benefits to governments need to be taken into account.

(2) Infrastructure, incentives and encouragements

Apart from the general arrangements that have to be made by governments, the authors would like to draw the readers' attention again to (i) the self-regulatory system run by fishermen themselves and (ii) the resources research and communication with fishermen.

a) Organization of fishermen

The authors believe that the Japanese-type fisheries cooperative system is one of the best ways to organize the self-regulatory system. Such a system, if it can be applied, must contribute toward management and conservation in other countries too. However, the Japanese system is closely related to the Japanese socio-economic conditions and is partly a result of Japanese policy including various incentives arranged by both central and local governments. Careful studies of the socio-economic conditions and legal framework in the country are strongly recommended in this regard too.

(b) Resources research and communication with fishermen

The communication between the research institutes and fishermen is another element to be highlighted in the effective enforcement of resources and fisheries management. In Japan there are eight national and regional

fisheries research laboratories and more than 150 prefectural and local fisheries experimental stations round the coast. The national institutes are rather academic, but the local institutes are highly fisheries oriented, communicating regularly with the local fishermen. Each of the prefectures bordering the sea has three to six stations dealing with research on fishery resources and aquaculture, fish farming and artificial seeding for fish culture, etc. Daily communication with fisheries co-operatives and their members is routine. Under such circumstances, the information from the stations is regarded by fishermen as their own. This has been very important to success of the self-regulatory system. If such information and encouragement had not been provided by public institutes, none of the co-operatives could have established biologically sound self-regulation or achieved proper enforcement of it.

In conclusion, when planning the establishment or adjustment of multispecies fisheries management, careful examination of all relevant factors has to be undertaken by the government, specifically (1) the environmental conditions and resources available, (2) the structure of the fisheries, (3) the socio-economic conditions of the fisheries and fishing communities, (4) the governmental infrastructure, (5) the costs and benefits of the enforcement of management.

These have to be done according to (i) the availability of funds and technical capabilities (research and enforcement), (ii) the current status of resources and fisheries, (iii) the socio-economic conditions in fishing communities and the status of the fishing industry among national industries, (iv) the outcomes expected in resources and fisheries and (v) the priority areas regarding national policy in the country.

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APPENDIX

Long-term changes in annual catch of major carnivorous fish species of high commercial value by type of change caught in the Seto Inland Sea, 1951-85 1/, 2/.

(ton)

Year	Type of change: Once depleted recovering later — Species: Bastard halibut	Red sea bream	Dagger-tooth pike-conger	Type of change: Stable before increasing later — Species: Japanese Spanish mackerel	Japanese sea bass	Lizard-fish	Large-head hair-tail	Total
1951	574	4 654	(2 526)	?	?	?	?	(12 927)
1952	375	3 593	2 526	(1 099)	(1 307)	(2 245)	567	(11 712)
1953	270	5 385	2 798	1 125	1 345	2 306	653	13 882
1954	450	4 609	2 254	1 073	1 271	2 183	480	12 320
1955	435	4 320	2 036	1 538	1 534	2 895	1 271	14 029
1956	390	4 579	2 018	1 703	1 541	3 270	1 800	15 301
1957	203	4 576	1 511	1 436	1 421	3 068	1 369	13 584
1958	140	3 870	1 237	1 514	1 464	2 651	2 467	13 343
1959	191	3 435	1 229	990	1 556	2 776	1 135	11 312
1960	206	3 245	1 252	1 329	1 636	2 905	1 083	11 656
1961	193	2 994	1 490	1 149	1 973	2 744	904	11 447
1962	136	2 539	1 190	1 184	2 104	2 992	1 401	11 546
1963	87	2 715	1 076	1 284	1 929	3 011	986	11 088
1964	92	2 764	1 158	1 573	1 802	2 090	876	10 355
1965	98	2 872	746	1 500	1 999	2 452	1 745	11 412
1966	114	2 696	710	1 912	2 039	2 678	3 504	13 653
1967	88	2 730	679	1 079	2 193	2 959	4 368	14 096
1968	152	2 450	673	1 143	2 245	2 531	4 126	13 320
1969	148	2 547	477	909	1 816	2 848	7 626	16 371
1970	204	2 033	680	1 790	1 518	3 107	9 528	18 590
1971	228	2 042	650	1 232	1 510	2 859	10 153	18 674
1972	209	2 060	614	1 480	1 712	2 767	16 913	25 755
1973	228	2 161	428	1 350	1 753	3 464	10 949	20 333
1974	267	2 288	381	1 172	2 381	3 554	11 949	21 992
1975	231	2 966	586	1 722	2 796	3 932	13 335	25 568

1976	323	3 138	384	2 467	3 124	4 366	13 734	27 536
1977	373	2 997	419	3 012	3 400	5 120	6 117	21 447
1978	415	2 895	290	3 173	3 748	5 382	9 096	24 999
1979	473	3 260	401	3 024	3 523	4 960	10 413	26 054
1980	443	3 623	473	4 045	3 538	5 412	14 893	32 427
1981	415	3 624	484	3 160	3 700	5 373	14 752	31 508
1982	437	3 722	425	2 986	3 301	4 557	16 918	32 346
1983	583	3 707	560	3 184	3 128	4 191	14 669	30 022
1984	664	4 708	618	3 893	2 903	3 989	15 592	32 367
1985	956	4 321	716	5 816	2 761	4 952	14 335	33 857

1/ Source:

a) Fisheries Agency, Japan (1976), for 1951-69,

b) Japanese Yearbooks of Fisheries Statistics, for 1970-1985.

2/ Figures in parentheses are estimates.

APPENDIX

Annual changes in aquaculture production by type of culture and major species in the Seto Inland Sea, 1969-85 1/, 2/.

(ton)

Year	Total production	Type of culture					
		Without feeding			With feeding		
		Total	Seaweeds	Shellfish	Total	Fish	Prawns
1969	238 552	228 314	80 080	148 234	10 238	10 030	208
1970	202 044	192 011	86 003	106 008	9 914	9 739	175
1971	233 539	223 003	87 424	135 579	10 439	10 241	198
1972	242 440	235 337	81 833	153 504	7 035	6 739	296
1973	312 868	302 172	132 118	170 054	10 640	10 322	318
1974	310 003	298 181	150 189	147 992	11 822	11 430	392
1975	282 063	270 189	123 864	146 325	11 874	11 549	325
1976	300 677	288 311	133 320	154 991	12 366	11 931	435
1977	278 991	269 201	122 722	146 479	9 790	9 388	402
1978	310 987	301 470	133 806	167 664	9 517	9 082	435
1979	304 267	292 327	145 036	147 291	11 940	11 354	586
1980	374 018	359 102	170 975	188 127	14 916	14 292	624
1981	343 358	326 110	152 159	173 951	17 246	16 499	747
1982	324 108	304 135	118 341	185 794	19 973	19 091	882
1983	361 641	341 372	153 953	187 419	20 269	19 436	833
1984	396 342	379 001	194 607	184 394	17 341	16 472	869
1985	346 966	329 219	149 607	179 612	17 747	16 832	915

Continued ------>

Major species cultured					Feed used for fish culture	
Seaweeds		Shellfish	Fish		Prawns	Total amount used	Fresh feed
Laver	"Wakame"	Oyster	Amberjack	Red sea bream	Kuruma prawn		fish, clams, shrimps, krill, etc.
77 392	2 688	148 234	9 866	?	208	65 329	(65 289)
80 958	5 045	106 002	9 656	11	175	71 913	71 762

81 712	5 712	135 577	10 183	27	198	75 054	75 001
72 481	9 348	153 503	6 506	178	296	74 794	74 755
115 720	16 398	170 054	9 751	497	318	87 183	85 788
127 769	23 420	147 985	11 086	292	338	80 508	80 366
112 137	11 727	146 325	10 899	594	325	91 173	90 912
112 802	20 518	154 987	11 388	483	393	88 391	87 803
101 265	21 457	146 450	8 778	542	386	69 498	69 015
111 311	14 495	167 628	8 031	903	424	74 111	68 740
128 434	16 602	147 268	9 826	1 256	564	86 233	84 800
152 060	18 915	188 108	12 732	1 313	602	116 777	115 135
131 355	20 652	173 925	14 899	1 273	739	106 173	104 558
97 324	20 942	185 776	17 179	1 601	872	128 340	125 952
132 578	21 255	187 376	16 341	2 730	833	94 304	(91 303)
172 398	21 884	184 356	15 012	1 218	868	97 141	(94 152)
128 696	20 577	179 579	14 893	1 311	914	94 351	(89 477)

1/ Source: Japanese Yearbooks of Fisheries Statistics.

2/ Figures in parentheses are estimates.

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